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PRIORITIES AND PROCEDURES FOR DEVELOPMENT OF STANDARDS OF PERFORMANCE FOR NEW STATIONARY SOURCES OF ATMOSPHERIC EMISSIONS

Argonne National Laboratory
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PRIORITIES AND PROCEDURES FOR DEVELOPMENT OF STANDARDS OF PERFORMANCE FOR NEW STATIONARY SOURCES OF ATMOSPHERIC EMISSIONS

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ABSTRACT

Because of the increasingly important role of New Source Performance Standards in the national air quality program and the large number of categories for which standards are being developed, a clearly defined procedure for selecting category priorities and establishing schedules for standard promulgation is a necessity. This report describes a methodology that has been developed for selecting priorities and schedules based on projected reductions in emissions resulting from the individual standards and other considerations related to technological, legal, institutional, and conservation factors. The methodology is used with available data to develop an initial standard-setting program. The program variations that result from alternate areas of emphasis are also presented. The expected future developments in emission control technology and various aspects of the process for developing standards are reviewed in terms of how they may affect the long-term New Source Performance Standards program.

1. EXECUTIVE SUMMARY

The promulgation of Standards of Performance for New Stationary Sources as mandated by Section 111 of the Clean Air Act is assuming an increasingly more prominent role in the national air quality program. This body of standards, commonly referred to as New Source Performance Standards (NSPS), reflect the long-term maximum limitation in stationary source emissions, taking into account cost, which is achievable without the imposition of restrictions on land use or industrial development.

Because of limitations on resources for developing the standards and other restrictions such as availability of emission testing and control technology, there is a constraint on the number of standards that can be developed in a given period. This report addresses the question of the impact on future emissions of these constraints on standard-setting rate and establishes priorities and schedules for future standard promulgation in view of alternate objectives or areas of emphasis. Over 300 potential and existing standards in 190 source categories were considered.

A methodology for prioritizing the potential standards is developed, which considers first of all for each pollutant the potential emissions reduction computed from estimates of source category growth and emission factors with and without NSPS. For the minimization of future emissions, priority factors based on potential reduction should also be weighted with the inverse of the time required to develop the standard.

The next step in the prioritization is a source-screening procedure that identifies for each industry/pollutant category other constraining factors that are not as easily quantifiable, but which may of necessity increase or decrease the category priority ranking. The factors considered include the status of emission measurement and control technology, legal and institutional constraints, impact on energy and other scarce resources, individual source impact, and others. The screening methodology relies on both a numerical ranking of some factors and a qualitative ranking of others. Alternative strategies wherein constraints are applied or relaxed are then evaluated for their impact on emissions, first for the individual pollutants and then for all pollutants simultaneously.

The objective of the methodology for prioritization is to provide a framework in which all of the assumptions that go into setting the priorities can be clearly defined and changes in areas of emphasis can be easily accommodated to obtain new priorities that reflect those changes.

Using the methodology described, an initial source category prioritization and alternatives were developed from compiled information. This initial prioritization is not intended to firmly establish the order in which NSPS should be set. Rather, it is intended to identify those industries and pollutants for which more intensive studies should be initiated to confirm or revise the priority finding. The priority evaluations should be a continuing process that accounts for new information or changes in emphasis.

For particulates, the evaluations in this study show that existing NSPS are insufficient to maintain future emission levels at 1975 levels. However, even with the delay of standards with constraining factors identified in the source screening process, the 1975 levels could be maintained with a nominal standard-setting rate for particulate sources of 6 per year. The largest uncertainty in this schedule is the need to promulgate particulate standards in the near future for intermediate size boilers. Additional information is also required to determine the desirability of augmented particulate standards to control fine emissions and hazardous trace substances.

For sulfur dioxide, emissions can only be maintained at the 1975 level by the NSPS mechanism if natural gas or other equivalent clean fuels become more readily available. Without these fuels or the development of significantly improved stack gas cleaning devices, SO_2 emissions are projected to increase by 22% by 1990. The current potential for SO_2 emission reduction has been largely exploited by existing regulations.

For nitrogen oxides, even with the application of maximum NSPS control efforts, a significant emission increase of more than 40% occurs in the 1975-1990 period. The maximum controls provide significant reductions through revised standards for large boilers and nitric acid plants. Control of internal combustion engines, through the resolution of problems of enforcement, should be a matter of high priority.

Existing NSPS for hydrocarbons have achieved only a small portion of the control potential and promulgation of additional standards can result in a significant reduction in emissions in the 1975-1990 period. Resolution of constraints on the industrial surface coating and ethylene oxide categories, combined with controls on the unconstrained sources, appears to be the most effective NSPS program.

Significant control of carbon monoxide emissions results from motor vehicle controls and therefore this pollutant is not of high priority for NSPS. Except for the iron and steel processes, adequate stationary source control can be attained by linking the NSPS for CO to standards for NO_x or hydrocarbons.

For the combined pollutant standard-setting schedule, the initial pollutant to be emphasized depends on the relative emissions limitation criteria. In the baseline strategy, initial emphasis on hydrocarbon NSPS is required to prevent the many uncontrolled categories from causing emission increases. A special priority emphasis on energy conservation causes only minor variation in projected emissions. Diversion of effort from development of NSPS for criteria pollutants (regulated by NAAQS) to those for noncriteria pollutants is possible without significant penalties in increased criteria pollutant emissions. An increased emphasis on emerging industries also results in slight increases in projected national emissions for all pollutants. Emphasis on sources that are covered under prevention of significant deterioration regulations results in some emission penalties for NO_x, hydrocarbons, and CO.

A consideration of the standard development procedure indicates that the current practice of preparing rather detailed supporting documents cannot be avoided without penalties of less stringent standards or increased involvement in litigation. With current resources the standard-setting rate is approximately 20 NSPS per year. This could be increased up to 80 per year through extensive use of contractors and by streamlining of the review process. The reduction in projected national emissions is, however, not in direct proportion to the increased standard-setting rate because of prior regulations for a majority of the major sources. As the number of promulgated standards increases, additional effort will be required for monitoring their impact, providing guidelines for affected sources, and developing necessary revisions.

The recently implemented procedure for preparing Environmental Impact Statements for NSPS will result in standards that are more easily defendable. This procedure should include preparation of periodically updated statements on the cumulative effects of all NSPS and comprehensive assessments of secondary impacts from frequently used control devices, such as wet scrubbers.

2. *INTRODUCTION*

The Clean Air Act of 1970[1] has mandated the use of several complementary approaches in a national program "to protect and enhance the quality of the nation's air resources so as to promote the public health and welfare ..." These approaches include:

a) National Ambient Air Quality Standards (NAAQS), which are to be attained on a regional basis through State Implementation Plans (SIP) (Sections 109 and 110);

b) Standards of Performance for New Stationary Sources, which reflect the degree of emission limitation achievable through the application of the best system of emission reduction, which has been adequately demonstrated, taking into account the cost of achieving such reduction (Section 111):

c) National Emissions Standards for Hazardous Air Pollutants (NESHAP) for stationary source controls of pollutants, which may cause serious health effects (Section 112);

d) Emission Standards for Moving Sources, which are required by the Clean Air Act to reduce mobile source emissions at least below a given level (Sections 202, 211, and 231); and

e) Abatement by Means of Conference (Section 115) and Emergency Powers (Section 303), which are lesser-used options.

The purpose of this report is to present a systematic analysis of the priorities and procedures relevant to long-range implementation of one of these programs, the development of Standards of Performance for New Stationary Sources (Section 111), commonly referred to as New Source Performance Standards (NSPS).

Development of NSPS, which reflect the best-demonstrated control technology (taking into account costs), is a complex and time-consuming process, and because of a limitation in the resources of manpower and funding available to the EPA, there is a restriction in the rate at which NSPS can be developed and promulgated. As a result of this limitation, it is mandatory that a procedure be implemented for establishing priorities for developing NSPS categories of stationary sources that reflect the objectives of this set of standards.

The overriding purpose of these standards, as intended by Congress, is to maintain existing air quality and to prevent new air pollution problems from developing in the future.[2] The implementation of Section 111 serves an additional role by contributing to the other air programs information related to emission factors, capability of control systems, cost alternatives, standard sampling methods, malfunction regulations, inspection procedures, etc. For noncriteria or "designated" pollutants (pollutants not listed under Section 108 requiring promulgation of NAAQS, or listed as a hazardous pollutant under Section 112) standards of performance apply to both new and existing sources and become the complete control strategy (Section 111(d)).

In the following Section 3 of this report, a methodology is presented for assigning priorities to the various categories of sources. This methodology considers first of all the potential reduction in emissions, which results from NSPS promulgation based on estimates of existing emission levels, available control technology, and projected growth rates. To this is added information related to other factors, such as expected developments in technology, availability of adequate emission testing methods, impact on fuel consumption or other limited resources, legal constraints, etc. A prioritization is then developed with this information in view of areas of emphasis based on an assessment of the broad EPA strategy for implementing the Clean Air Act.

An application of the developed methodology for priority evaluation is presented in Section 4 using data on potential emissions reduction, which have been provided by The Research Corporation of New England[3,4] and information on areas of emphasis and other additional factors that were compiled in this study. The result of this evaluation is an initial prioritization using a baseline set of data and assumptions on the relative importance of areas of emphasis. Also included are alternative priorities that would result from changes in areas of emphasis or changes in other factors, such as availability of alternative fuels or new technology.

Because of the importance to the prioritization of available emissions control technology, Section 5 is devoted to a discussion of the current status of these technologies and expected developments as a result of ongoing research.

In Section 6, the procedures and requirements of the standard development process are considered. Topics that are discussed include the need for more detailed and on-going category prioritization and scheduling, the standard rationale, review of the proposed standard, use of contractors in standard development, enforcement and revision of standards, and preparation of Environmental Impact Statements.

The basis for emission projections for mobile sources used in estimations of total national emissions is presented in Appendix A.

3. PRIORITIES FOR NEW SOURCE PERFORMANCE STANDARDS

3.1 PRIORITY REQUIREMENTS

In carrying out the mandate of Section 111 of the Clean Air Act, the EPA is faced with the Herculean task of setting New Source Performance Standards for over 200 source categories and at least 5 pollutants. Each industry represents a unique system of emission sources, control options, and qualifying constraints that makes the standard-setting process a complex and involved procedure if it is to be done in a technically and economically sound fashion. Given a limited amount of resources available to carry out the process, it is necessary to establish a system of priorities to concentrate efforts on the most important areas first, while postponing less important areas for later consideration. In terms of the NSPS process, this means setting standards for some industries and pollutants while leaving others controlled at existing state standard levels until sufficient resources are available to carry out the necessary studies for a standard to be set.

To date, standards have been set for 12 industry categories and 6 pollutants. As would be expected, the question has often been raised as to why these specific industries and pollutants were chosen over all others. Similar questions will, no doubt, be raised every time a new standard is proposed. A rational system of setting priorities is necessary to define the reasons for choosing one category over another and to make the NSPS process a more efficient means of air quality management. At the same time, a well-designed prioritization methodology can be used as an air quality planning tool to determine where technological, legal, and institutional improvements are necessary to realize emission reductions.

No prioritization procedure, the one to be presented here included, can expect to engender universal agreement on the factors that are most important and the resulting priority listing. The most that can be hoped for is that all of the assumptions that go into setting the priorities will be clearly defined and that challenges to the prioritization can be made on the basis of an agreed-upon set of ground rules. The methodology to be described here does not rely on the use of a single numerical ranking of industry/pollutant categories since such a process would tend to obscure the assumptions and decisions that go into the method and the loss of this information can result in controversy and confusion. Instead, the methodology relies on both a numerical ranking of some factors and a qualitative ranking of others. The technical judgment of the one establishing the priorities will, of necessity, play a key role in the relative importance of each factor, but if the rationale behind each decision is clearly outlined and documented, there can be little cause for confusion.

One additional point needs to be made about the prioritization methodology presented here. This is not intended to establish the order in which NSPS should be set. Rather, it is intended to identify those industries and pollutants on which intensive studies should be initiated in preparation for the setting of a standard. These more detailed studies may confirm or dispute the findings of this priority scheme, but the procedures presented here will, nevertheless, provide a starting point from which to determine resource allocations.

The methodology consists of three major parts: 1) Model IV calculations, 2) source screening, and 3) emission projections.

3.2 SOURCE RANKING METHODOLOGY

Figure 3-1 is a sample form used to evaluate each industry category and pollutant. It provides a uniform method of tabulating the various considerations that go into the source prioritization. In many cases, it was not possible to fill in the form completely due to a lack of information. Nevertheless, the evaluations that could be made from the available data provide a useful framework for the source ranking. To simplify the discussion of these evaluations, the 10 factors on Fig. 3-1 will be referred to by their number on the form. The first factor, Special Priority, is discussed in Section 3.3. Factor 2, the Model IV Data, is discussed in Section 3.2.1, and Factors 3-10 in Section 3.2.2.

3.2.1 Model IV Calculations

The use of the emission computation procedure referred to as "Model IV" has been described in detail elsewhere[3] and will be summarized here only briefly.

Model IV was developed by George Walsh of the EPA's Emission Standards and Engineering Division and is the latest methodology in an evolving emission

INDUSTRY ______________________

POLLUTANT ______________________

Source Evaluations   Special Considerations

1. Special Priority ______________
   ____

2. Model IV Data
   En ______________
   Ts-Tn ______________
   Rank ______________

3. Control Technology Evaluation
   a. Type ______________________________
   b. Status ______________________________
   c. Cost ______________________________
   d. Availability ______________________________
   e. Other ______________________________

4. Emission Measurement Evaluation
   a. Method ______________________________
   b. Feasibility ______________________________
   c. Applicability ______________________________
   d. Other ______________________________

5. Enforceability Evaluation
   a. Technical ______________________________
   b. Legal ______________________________
   c. Equipment Standard ______________________________
   d. Other ______________________________

6. Individual Source Impact Evaluation
   a. Typical Source Size ______________________________
   b. Source Location ______________________________
   c. Other ______________________________

7. Energy Impact Constraint Rating ______________________________

8. Scarce Resource Constraint Rating ______________________________

9. Other Environmental Media Constraint Rating ______________________________

10. Other Considerations ______________________________

Overall Rank ______________

Fig. 3-1. Standard Industrial Evaluation Form

source priority rating system that is based on determining the relative impact of NSPS on industrial emissions. The fundamental prioritization parameter generated by the model is the "additional control potential" of new or revised NSPS relative to baseline year control regulations. This parameter is denoted as (Ts-Tn) where

Ts = total emissions under control regulations existing in the baseline year and

Tn = total emissions under new or revised NSPS.

By computing this parameter for a given year for each individual source category, it is possible to determine what emission reductions could be achieved by NSPS above and beyond current state regulations. Promulgation of standards for sources with the largest Ts-Tn values would result in the greatest emission reductions while control of sources with small Ts-Tn values would have little impact on national emission rates. This rating can be used as one means of establishing a hierarchy for the setting of standards within the confines of limited resource availability.

Table 3-1 lists the parameters considered in the Model IV calculations. The industrial capacity parameters are a measure of the level of emission-producing activity of the source category. New Source Performance Standards, when promulgated, are applicable to the capacities B and C that represent the replacement of obsolete facilities and the construction of additional capacity, respectively. The baseline year capacity A is subject to state regulations only. The fractional utilization K accounts for unused capacity.

The industrial growth parameters are used to measure the rate of expansion of an industry both in the replacement of obsolete facilities and in the construction of new facilities. The growth rates P_B and P_C may be simple or compound. It is intuitively obvious that industries with large growth rates should have standards promulgated as soon as possible to bring the large number of new plants and facilities under best available control. The production capacities B and C are related to the growth rates by Eq. (3-1) and (3-2):

$$\begin{aligned} B &= A\,[(1 + P_B)^i - 1] \\ C &= A\,[(1 + P_C)^i - 1] \end{aligned} \qquad (3\text{-}1)$$

for compound growth;

Table 3-1. Parameters for Determining Ts-Tn by Model IV

Parameter	Symbol	Factor	Units
Industrial Capacity	K	Fractional utilization of existing industry capacity	
	A	Baseline year production capacity	Production units/year
	B	Production capacity from construction and modification to replace obsolete facilities	Production units/year
	C	Production capacity from construction and modification to increase output above baseline year capacity	Production units/year
Industrial Growth	P_B	Construction and modification rate to replace obsolete capacity	Decimal fraction of baseline capacity/year
	P_C	Construction and modification rate to increase industry capacity	Decimal fraction of baseline capacity/year
Emissions	E_u	Emissions with no controls	Mass/unit capacity
	E_s	Allowable emissions under existing regulations	Mass/unit capacity
	E_n	Allowable emissions under new or revised NSPS	Mass/unit capacity
	$E_{111(d)}$	Allowable emissions for existing sources as required by Section 111(d) of the Clean Air Act	Mass/unit capacity

$$B = A\ i\ P_B \qquad (3\text{-}2)$$

$$C = A\ i\ P_C$$

for simple growth,

where i is the elapsed time in years.

The emission rates are used to determine the magnitude of the emission impact of each source category. In addition to the uncontrolled, state-regulation-controlled, and NSPS-controlled emission rates, there is an emission rate to reflect the promulgation of an NSPS for a noncriteria pollutant. Under Section 111(d) of the Clean Air Act, such a promulgation mandates the states to implement control strategies for that pollutant for both new and existing facilities. The emission rate $E_{111(d)}$ reflects the emission regulation for existing facilities.

All of the Model IV parameters are incorporated into the Ts-Tn value of additional control potential by Eqns. (3-3) through (3-5):

$$Ts = E_s\ K(A-B) + E_s\ K(B+C) \qquad (3\text{-}3)$$

$$Tn = E_s\ K(A-B) + E_n\ K(B+C) \qquad (3\text{-}4)$$

$$Ts-Tn = K(B+C)\ (E_s-E_n) \qquad (3\text{-}5)$$

For noncriteria pollutants, Tn is redefined by Eq. (3-6):

$$Tn = E_{111(d)}\ K(A-B) + E_n\ K(B+C) \qquad (3\text{-}6)$$

For cases where the state standards differentiate between new and existing sources, Ts and Ts-Tn are redefined by Eq. (3-7) and (3-8):

$$Ts = E_{s\ exist}\ K(A-B) + (E_{s\ new})\ K(B+C) \qquad (3\text{-}7)$$

$$Ts-Tn = K(B+C)\ (E_{s\ new} - E_n) \qquad (3\text{-}8)$$

The Ts and Tn values may be computed for any year of interest. In both cases, the year in which the NSPS is promulgated determines whether the industrial growth is controlled under state regulations (i.e., E_s) or NSPS (i.e., E_n). For the Ts-Tn calculations made by TRC,[3] it was assumed that the standard was set in 1975 and the impact on 1985 emission rates was determined.

Factor 2 on the standard industrial evaluation form of Fig. 3-1 is the Model IV data. The items of special interest are the values of En, Ts-Tn, and the Ts-Tn rank. The Ts-Tn rank is the numerical order of the source category relative to the Ts-Tn values of all other sources. The source with the largest value of Ts-Tn for a given pollutant is first with other sources following in sequence. As indicated before, this rank established a prioritization that can be used to set standards. In the following methodology, this rank is used to order the sources within the various groupings and represents the fundamental hierarchy. This order is superceded by consideration of the constraints and restrictions on the setting of standards for the source.

The prioritization using Model IV parameters can be extended to include the effect of the differing amount of time required to develop each of the standards. The importance of this additional parameter becomes obvious by considering the simple case of two separate categories with identical Model IV values; intuitively, priority should be given to the category for which standard development is nearest completion. This concept can be generalized by the following analysis of two source categories X and Y, which are to be prioritized. Let $E_{s,X}$ and $E_{s,Y}$ be the allowable emissions under existing regulations for categories X and Y, respectively, and $E_{n,X}$ and $E_{n,Y}$ be the corresponding emissions under NSPS. The annual growth rates in new and modified capacity for categories X and Y is, respectively,

$$P_X = P_{B,X} + P_{C,X} \tag{3-9}$$

and

$$P_Y = P_{B,Y} + P_{C,Y} . \tag{3-10}$$

The time required to develop the respective standards is t_X and t_Y.

With the above assumption, by developing the standard for category X followed by development of the standard for Y, the combined emissions from new or modified sources initiating construction during the standard development period for both standards is:*

---

*For the relatively short time periods covering standard development, simple growth rates can be assumed. However, for compound growth, the annual growth rate as used in this development is dependent on the year of analysis.

$$\Delta T_{XY} = [E_{s,X}\, t_X + E_{n,X}\, t_Y]\, P_X K_X A_X + [E_{s,Y}(t_X+t_Y)] P_Y K_Y A_Y \;, \qquad (3\text{-}11)$$

where $K_X A_X$ and $K_Y A_Y$ are initial production rates. On the other hand, developing the standards in reverse order results in new emissions:

$$\Delta T_{YX} = [E_{s,Y}\, t_Y + E_{n,Y}\, t_X] P_Y K_Y A_Y + [E_{s,X}(t_Y+t_X)] P_X K_X A_X \;. \qquad (3\text{-}12)$$

The new emissions growth after both standards are set is independent of the order in which the standards are set and therefore the priority depends on the relative magnitudes of Eqs. (3-11) and (3-12). Taking the difference of these equations gives:

$$(\Delta T_{XY} - \Delta T_{YX}) = [(E_s - E_n)PKA]_Y\, t_X - [(E_s - E_n)PKA]_X\, t_Y \;, \qquad (3\text{-}13)$$

which can be positive or negative depending on the values of the parameters. By considering the implications of this relation, it can be easily shown that minimum emissions will occur if highest priority is given to the category with largest value for the

$$\text{Priority Factor} = \frac{(E_s - E_n)(P_B + P_C)KA}{t_{SD}} \qquad (3\text{-}14)$$

where t_{SD} is the time required for standard development. The appearance of the development time in the denominator tends to increase the priority of standards that are nearer to promulgation because of, for example, having received prior partial development or being revisions to existing standards.

For fixed development time t_{SD}, the prioritization based on Eq. (3-14) would be in most cases equal to that based on Ts-Tn given above. For the quantitative study described in Section 4, the Ts-Tn prioritization was used because of lack of sufficient information to determine t_{SD} values.

Further details on the development of the Model IV data base are given in References 3 and 4.

3.2.2 *Source Screening*

The Model IV calculations provide an insight into the relative importance of the various sources based on the parameters listed in Table 3-1. There are, however, other factors that are not as easily quantifiable, but that also influence the priority ranking of the industry/pollutant categories. It is the purpose of the source-screening procedure to provide a mechanism whereby these factors may be incorporated into the overall prioritization.

Table 3-2 lists the screening factors used in this methodology, the items considered for each factor, and the possible "flags" that will influence the priority ranking of the source category under consideration. The factor numbers refer to the position of each on the standard form of Fig. 3-1.

Factors 3 through 6 involve an evaluation of the items listed and a judgment as to whether there are any major obstacles to the setting of a standard. The flags are those obstacles that have appeared most frequently in the application of this methodology in this study. Factors 7 through 9 are an evaluation of constraints that may not pose an obstacle to the setting of a standard, but may result in a shifting of the order in which the standards are set. In general, a ranking of 1 indicates little or no constraint on the setting of a standard as imposed by the factor. A ranking of 2 indicates a moderate constraint, and a ranking of 3 indicates a severe constraint, which may hamper the promulgation of a standard. A ranking of 0 is included to indicate that the setting of an NSPS may have a positive effect on the factor considered. It should be emphasized that the numbers used to indicate constraint ranking are not intended to indicate relative magnitudes of the constraints. A ranking of 2 does not necessarily mean a constraint twice as heavy as a ranking of 1. Factor 10 is for any other consideration, the most frequently occurring of which is an already-promulgated NSPS.

Control Technology Evaluation (Factor 3)

This review is designed to determine, in a qualitative way, the control options that are available for the industry/pollutant under consideration. The first item considered is the type of control system available. These may include stack gas cleaning equipment, process modifications, or design changes. Where several options are available, all are included in the evaluation. A significant finding to come from this review is an identification of those sources for which there is no control technology available apart from the cessation of operation. These sources are flagged with a NC and must, of necessity, be moved to the end of the priority list, since there is no manner

Table 3-2. Source Screening Factors

Factor Number[a]	Factor	Items Considered	Possible Flags[b]
3	Control Technology	a. Type of control	NC - no control available apart from cessation of operation
		b. Status of control technology	RD - research and development needed
		c. Cost	HC - high cost associated with control
		d. Availability of control equipment	AV - the supply of control equipment presents a compliance problem
4	Emission Measurement	a. Method of measurement	NM - no method exists for the measurement of the pollutant
		b. Measurement feasibility	NF - measurement is not feasible from the source
		c. Measurement applicability	NS - measurement is not routinely applicable for surveillance
5	Enforce-ability	a. Technical problems	TE - technical problems for enforceability
		b. Legal problems	LE - legal problems for enforceability
		c. Equipment standard	EQ - an equipment standard may be preferable to an emission limit
			FS - a fuel standard may be preferable
6	Individual Source Impact	a. Typical source size	FL - few large sources
		b. Source location	WS - widespread small sources
			LO - source is location sensitive

Table 3-2. (Contd.)

Factor Number[a]	Factor	Items Considered	Possible Flags[b]
7	Energy Impact Constraint	Effect of standards on energy consumption	0 - standard would result in energy conservation 1 - little or no effect on energy consumption 2 - moderate increase in energy consumption 3 - severe increase in energy consumption
8	Scarce Resource Constraint	Effect of standards on the use of scarce resources	0 - standard would result in scarce resource conservation 1 - little or no effect on scarce resource use 2 - moderate increase in scarce resource use 3 - severe increase in scarce resource use
9	Other Environmental Media Constraint	Effect of standards on other air pollutants, water pollution, solid waste, thermal discharge	0 - standard would result in control of other environmental pollutants 1 - little or no effect on other environmental pollutants 2 - moderate increase in other environmental pollutants 3 - severe increase in other environmental pollutants
10	Other Considerations	Any other consideration affecting the priority ranking	ES - existing NSPS

[a] Based on the order of the standard form in Fig. 3-1.

[b] A flag of U indicates a factor in which there is significant uncertainty. For example, a flag of 3-U indicates considerable uncertainty in the control technology assessment (factor number 3) resulting from, perhaps, a lack of prior experience with control equipment on the particular source.

in which compliance with a regulation may be achieved. In some instances, the promulgation of a standard that effectively prohibits the operation of the source may be desired if the emissions are such that there is a significant health and welfare penalty to be paid by allowing the emissions to go uncontrolled. Open-burning is an example of this type of source category. It will be discussed in more detail later.

The second item considered is the status of the control technology. Where there is a demonstrated control technique that is in use, then no flag is necessary. Likewise, when a control option is available, but has not been widely used in the industry, no flag is used. If, on the other hand, the control system (including process and design modifications) is under development or requires a technology transfer from another similar industry and is not in widespread use, then the source category is flagged with an RD indicating that additional research and development is necessary before an NSPS can be set. These industry/pollutant categories are also shifted further back in the priority ranking to allow time for the control technology to be developed.

The third considered item is the cost of control. In some cases, there is a demonstrated control technology, but the cost of applying it is prohibitively high. In this case, the industry category is given an HC (high cost) flag. Given the manner in which the screening system is set up, there might be some argument to include cost as a constraint evaluation and rank it as a 0, 1, 2, or 3. There is some validity to this approach, but the purpose of the evaluation is to identify sources for which cost is an overwhelming obstacle. It does not seem reasonable to develop a priority standard setting procedure based on relative costs of control, since this is probably better handled by adjusting the magnitude of the standard rather than the order of standard setting. It should be emphasized that no attempt was made to do a comprehensive cost analysis. Instead, the intent was to identify special industry categories where the cost of control would be unusually high.

The fourth item is the availability of control systems. If an industry can be expected to encounter severe problems in obtaining the necessary equipment or materials for control, it is given an AV flag.

Emission Measurement Evaluation (Factor 4)

This review considers the measurement of emissions from the source. The first item considered is the determination of whether a method exists to measure the pollutant of concern from the source. For the criteria pollutants the published reference methods are available. For some noncriteria pollutants there may not be a recognized method for determining the emission rate as would be required for compliance testing, and such categories would be given an NM flag.

The second item is the feasibility of making an emission measurement from the source. In general, if the emissions are released through a stack, it is feasible to conduct some tests for compliance. If the emissions are from nonpoint sources, it is difficult (if not impossible) to measure emission rates and the industry is given an NF flag.

The third item is the applicability of the emission measurement for routine surveillance. As before, this would apply primarily to noncriteria pollutants and is designed to identify situations where the analysis of samples is too extensive and complex to be used routinely. This might occur, for example, in analysis for certain trace metals. An NS flag is given to indicate this condition.

Enforceability Evaluation (Factor 5)

This review considers whether or not an enforceable NSPS can be designed within the requirements of the Clean Air Act and subsequent judicial rulings. Technical problems are the first item considered. These would include uncertainties in the definition of a source category and the need to subdivide a category to develop realistic standards, difficulties in determining compliance with a standard, and the lack of information on source emissions (applicable especially with regard to new technologies). Industry/pollutant categories experiencing these types of obstacles would be given a flag designation TE.

Legal problems are the second item considered, and these include the authority to promulgate an NSPS for a category, overlapping regulations, public demand for control based on the nature of the emissions (e.g., pathological incinerators), and the lack of sufficient EPA manpower resources to ensure source compliance. Categories with these problems are flagged with an LE.

The third item considered is the possible use of an equipment standard in preference to an emission limit. This consideration also includes a fuel standard where control is achieved by specifying the fuel used. The flags used are EQ (equipment standard) and FS (fuel standard). The need for this type of NSPS can be dictated by two different conditions. In one case, it may not be feasible to design an emission standard due to measurement problems. In this situation, the industry category would also have flag notations in the emission measurement evaluation. In the other case, there may be such a large number of sources that it would not be feasible to enforce a standard that would require individual source testing. The direct firing of meat category presents such a problem. Under these circumstances, an equipment or fuel standard is the only reasonable way to control the source. There is, however, some question as to whether this type of standard meets the requirements of Section 111 of the Clean Air Act. The standards for petroleum storage vessels have been promulgated in this form primarily for the first reason (i.e., emission measurement is not feasible). It is not clear what the legal interpretation might be for an equipment standard set for the second reason. In any case, EPA policy must be established for these sources prior to the promulgation of an NSPS.

Individual Source Impact (Factor 6)

This review of typical source size and location is designed to identify special characteristics of individual sources. Sources that are widespread throughout the country are flagged with WS, sources that are few in number and tend to be large installation are flagged with FL, and sources that have especially sensitive locations (e.g., in urban areas) are flagged LO.

Energy Impact Constraint (Factor 7)

The application of air pollution control systems can result in an increase in energy consumption due to the power requirements of the equipment, a decreased efficiency of the process, or the requirement for a clean burning fuel to minimize emissions. The ratings of 1, 2, 3 are designed to give a perspective on the energy impacts of NSPS on each industry. The numerical rankings are not designed to indicate relative magnitudes of the impacts but only qualitative judgments. The ranking of 0 is included for source categories where NSPS promulgation can result in energy savings.

Scarce Resource Constraint (Factor 8)

In some instances, air pollution control requires extensive use of scarce resources, such as rare metals. Systems that require the use of a catalytic control device fall into this category most frequently. Although not representing an insurmountable obstacle, this consideration may dictate a postponement of standards in the interest of conserving these materials, or alternatively, influence the level of control to be achieved under the assumption that a less-stringent standard may be met with a different control technique. If another control option was available besides one that required scarce resource utilization, then the source category was given a rating of 1. Ratings of 2 or 3 were given to those categories for which there was no cost-effective alternative.

Other Environmental Media Constraint (Factor 9)

Air pollution control cannot be considered separately from other environmental media. When an air pollutant is controlled at the expense of water quality or through the creation of a solid-waste problem, little has been gained in compliance with the national policy of environmental protection. Similarly, control of one air pollutant that results in the increase in emissions of another may be of questionable desirability. This evaluation is designed to flag industries with these problems in the interest of identifying the need for cross-media studies prior to NSPS promulgation. On the other hand, those industries for which an NSPS can have a synergistic effect in controlling other emissions and effluents are identified as having increased desirability for standard development.

Other Considerations (Factor 10)

This consideration is for any item that cannot be classed elsewhere and might influence the priority ranking. The most frequently used flag is ES, indicating the existence of an already promulgated NSPS. While this does not preclude the development of a revised standard it might indicate a lower priority concern until standards have been set for all industries.

3.2.3 *Emission Projections and Standard-setting Schedules*

Using the Model IV data and the source-screening methodology, it is possible to develop an ordered list of source categories for the setting of NSPS. Sources with no major constraint are considered first, while others with increasingly more severe constraints are postponed. The next questions that must be answered are how the order of the sources will affect the emission rates at various points in time and what tradeoffs are possible to maximize the emission reductions while making allowance for the individual source constraints. To obtain these answers, a computation scheme was developed that used the Model IV data to calculate total emissions from all sources as a function of time and of the NSPS standard-setting strategy.

The general algorithm constructed for developing the prioritization and computing the resultant impact on emissions can be used for single or multipollutant analyses. It proceeds by evaluating at discrete points in time the need for standards and their future impact. Beginning in 1975 (or any other initial time), the evaluation is repeated at each time increment (6-month increments were used in this study) and continues sequentially until the final time is reached (1990 in this study). At each time t the following analysis procedure is used:

> Step 1. Set standards for all categories that have been explicitly scheduled for promulgation at time t.
>
> Step 2. If the number of standards set is greater than or equal to an established maximum, the analysis proceeds to time $t + \Delta t$.
>
> Step 3. Compute the projected emissions based on standards already set at time t or earlier, making use of Model IV Eqs. (3-3), (3-4), and (3-7). Based on these calculations, determine the pollutant with highest priority because of projected emissions exceeding goals or criteria.
>
> Step 4. If no goals or criteria are exceeded and the number of standards set at time t is greater than an established minimum, return to Step 1 for the analysis at time $t + \Delta t$.
>
> Step 5. For the priority pollutant, select for standard promulgation the highest ranking source category as determined by the screening methodology. Skip those categories that have been explicitly scheduled for standard promulgation at a time t' not equal to t, or alternatively are constrained to having standards set after time t', which is greater than t.

Step 6. If the number of standards set at time t is less than an established maximum, return to Step 3 to determine the next standard to be set at time t. If the number is greater than or equal to the maximum return to Step 1 for the analysis at time t + Δt.

Because of the well-defined structure for the prioritization algorithm, a computer program can be easily written to carry out the analysis. In fact, this becomes a necessity when the number of categories is large and if numerous reevaluations are necessary to determine the effect of alternate criteria or assumptions.

The option for specifying explicit overriding dates at which a standard will be promulgated (Step 1 above) is useful for including, for example, categories for which standards currently existing are proposed, under development or scheduled for development. Preventing a standard from being set prior to a given date (Step 5) simulates categories such as those that require an intervening period for further development of control technology.

The specification of the maximum number of standards that can be promulgated at any time (Steps 1 and 6) can be interpreted as units of resources (manpower, funding, etc.) available for standard promulgation. Associated then with each standard to be set is a number indicating the units of resources required to develop that standard. For example, for categories that require twice the normal resource for standard development (such as for a large, diverse category) only one-half as many standards can be set at any one time.

If a standard is being set for a pollutant within a category (Step 1 or 5), the standard for one or more additional pollutants from that category can also be set if appropriate. Examples of the application of this option occur when a single control system reduces emissions of more than one pollutant. The resources required to develop standards for additional pollutants simultaneously is generally less than that required for the first pollutant.

In many instances, emissions can be reduced by future revision of NSPS as control technology develops and experience in its application is accumulated. The above algorithm is easily expanded to include the possibility of revised standards. This expansion includes a checking procedure for preventing a revised standard from being promulgated before a minimum delay time has passed, since the passage of the initial NSPS. This minimum delay time is not required if the initial new source standard is a state standard.

When applying this algorithm to the analysis of a single pollutant, the concept of a "priority pollutant" is not used. Instead, the order in which the standards are set is determined by the source screening methodology subject to the imposition of limits on standard-setting rate and specifications of time periods in which a standard can or cannot be set.

The standard-setting priorities to be described in this study were based primarily on achieving and maintaining as nearly as possible predetermined levels of national emissions for each pollutant. These emission goals were determined first of all on the basis of absolute levels, relative to 1975 emission rates, needed to satisfy national ambient air quality goals, and secondly on the basis of reductions that are technically feasible, as indicated by the separate evaluation of NSPS priorities for each pollutant. The national emission levels, which would result in the attainment and maintenance of the National Ambient Air Quality Standards (NAAQS), cannot be precisely defined without the spatial disaggregation of emissions to at least an Air Quality Control Region (AQCR) level, since offsetting emision increases and decreases in separate areas can result in new or continued violations of NAAQS, while total emissions are decreasing. Without going to a disaggregated analysis, specification of national emission goals is restricted to more qualitative judgments based on considerations such as the number and severity of NAAQS violations and their potential impact.

The difficulty in establishing precise national emission goals is not as constraining a problem in establishing NSPS priorities as might be initially supposed because of the importance of the second consideration, the potential for control via NSPS with application of "best available control technology." This potential for control determines the maximum reduction achievable under Section 111 of the Clean Air Act as opposed to that reduction that is required for the attainment of the NAAQS. This maximum reduction, however, cannot be achieved because of constraints to NSPS promulgation, and it is only in the determination of how this deviation from maximum reduction will be apportioned among the pollutants considered that national emission goals have a role. The importance of additional Clean Air Act mechanisms in meeting the NAAQS, such as State Implementation Plans and mobile source controls, is clearly evident.

Having defined the maximum emission level goal, the priority pollutant at time t was determined (Step 3) by computing the minimum emissions that will occur at each point in time in the future (at times greater than t) if no standards are set for that pollutant at time t. This minimum occurs under the assumption that all remaining standards are set at time t + Δt. The priority pollutant is that with largest value of projected minimum emissions relative to the established emissions goals for that pollutant, and is illustrated by the ratio A/B in Fig. 3-2.

The rationale for using the minimum projected emissions for evaluating priorities is that the growth in new source emissions that occurs during the period between times t and t + Δt is the only penalty that can be directly related to not setting standards at time t, since any additional loss in control of new source emissions can be prevented by standards set at time t + Δt. Although assuming that all standards can be set at the following time t + Δt is not completely correct, the alternative of determining the priority pollutant on the assumption that no standards will exist in the future other than those promulgated previous to time t gives an even less realistic projection. An optimal analysis in the strict sense would simultaneously consider all possible standards in all time periods, but this becomes extremely complex because of the nearly infinite number of combinations possible.

A possible variation to the above procedure for determination of priorities is based on the total integrated emissions over the period under consideration as opposed to selecting for evaluation the maximum emission rate at any one point. Also considered was the possibility of basing the prioritization on projections of growth (using, for example, the OBERS[13] projections) in regions that are expected to have difficulty meeting NAAQS. In addition to the enormous amounts of data that must be managed, the problem of the questionable validity of projections of growth for a particular industry category in a small geographic area prompted the rejection of this approach.

3.2.4 Efficiency Ratio

With the large volume of data that can be generated from the emission projection routines, it is desirable to have one single measure of how each prioritization strategy compares to others for use as an initial evaluation. The measure chosen for use here is the effectiveness of a particular strategy

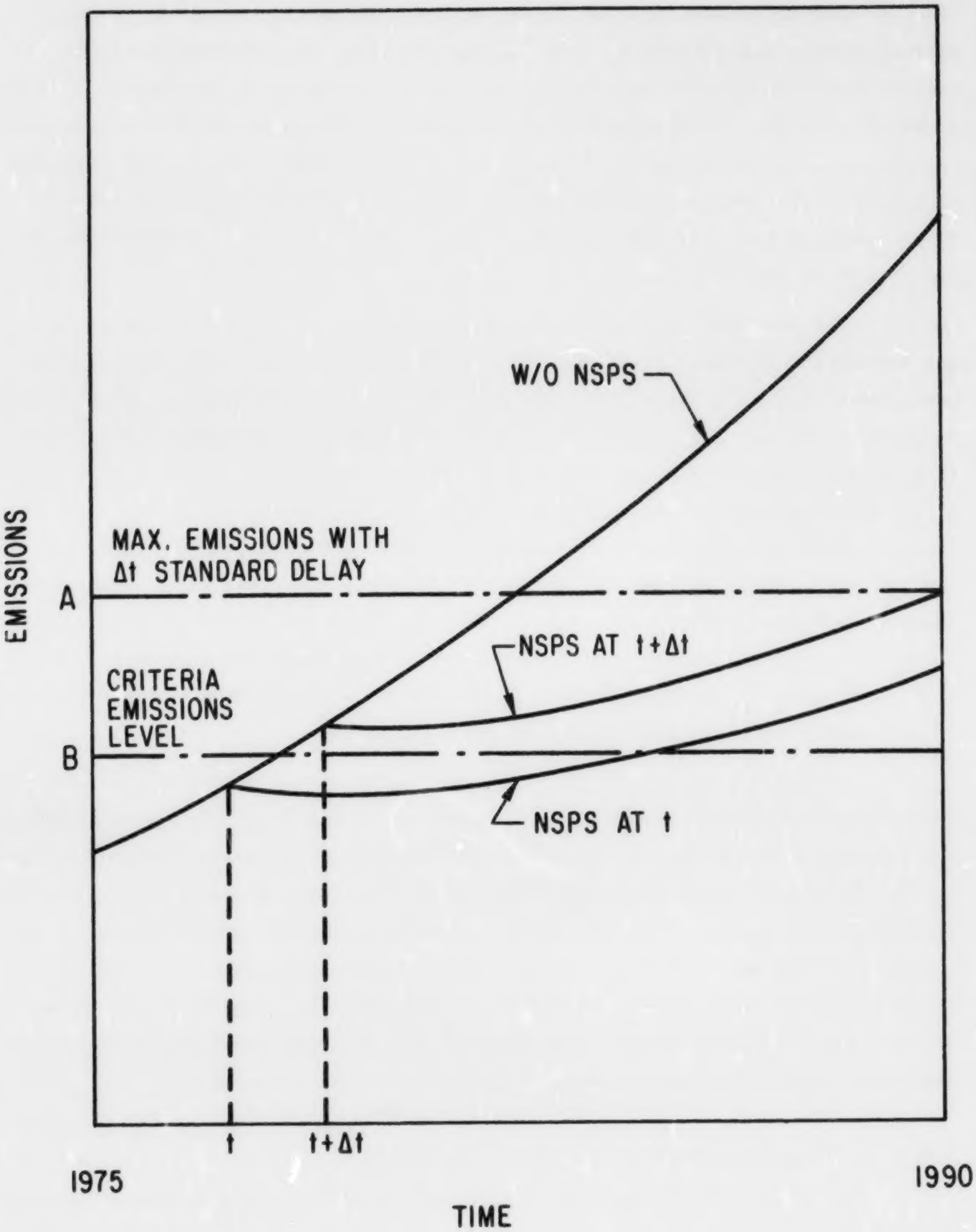

Fig. 3-2 . Emission Projections with and without NSPS in reducing emissions relative to the maximum achievable reduction. This effectiveness is termed the "efficiency ratio" and is given by:

$$\text{Efficiency Ratio, \%} = \frac{E_{max} - E_p}{E_{max} - E_{min}} \times 100 \qquad (3\text{-}15)$$

where E_{max} is the maximum emissions that would result from no further promulgation of NSPS (i.e., the implementation of existing standards only), E_p is the emissions resulting from the standard-setting prioritization under study, and E_{min} is the minimum possible emissions that would result from the setting of all NSPS immediately, excluding those where cessation of operation is the only feasible control option.

All quantities on the right-hand side of Eq. (3-15) are computed for a given point in time. It is evident that the efficiency ratio changes with time, depending on the prioritization strategy. From the nature of the Model IV procedures, it is also evident that the efficiency ratio will tend to level off at some value less than 100%. This is a result of the fact that the Model IV calculations assume that individual facilities that are built prior to NSPS promulgation continue at their uncontrolled emission rate indefinitely. The time scale considered is not long enough to have all these sources become obsolete. Because of the asymptotic approach of the efficiency ratio to a constant value, it becomes a useful measure of the prioritization strategy's effectiveness; this is especially true when it is computed for the last time period (i.e., 1990). Figure 3-3 gives an example of the computed efficiency ratio as a function of time for several hydrocarbon prioritization procedures. The asymptotic approach to a constant value is evident for all cases except when the standard-setting pace is too slow for all the standards to be set in the time frame considered. Even in this case, however, the value of the efficiency ratio computed in 1990 provides a first-order rating of the prioritization strategy relative to other procedures. In the following analyses, therefore, the 1990 efficiency ratio is used as a measure of priority effectiveness. (The unusual slope of the curves in the late 1970's is the result of the particular hydrocarbon standard-setting strategy used in this example. Standards for some large sources have been delayed due to some constraints and the slope of the curve changes sharply when they are finally set. This will become evident in the discussions in Section 4.)

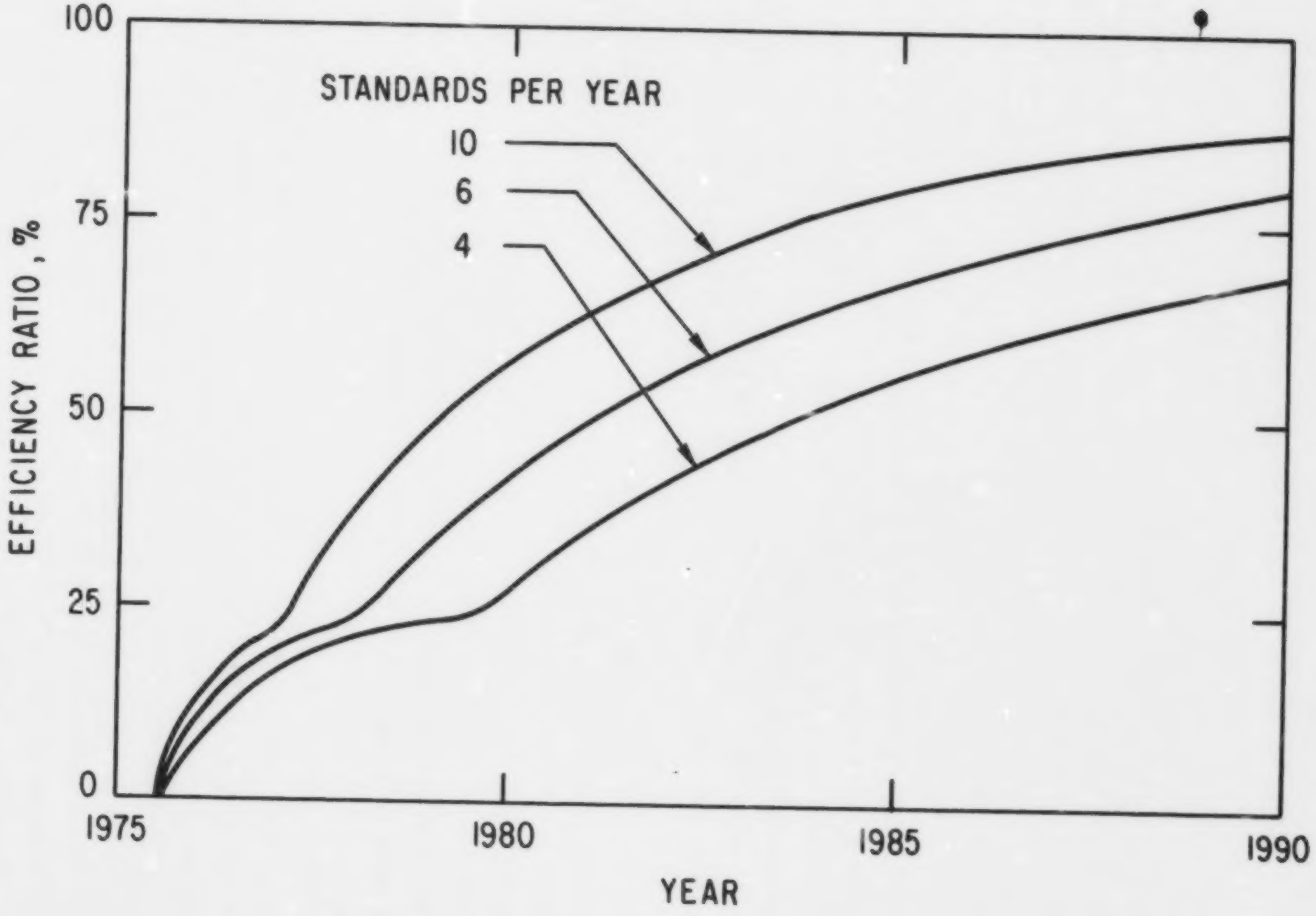

Fig. 3-3. Example of Efficiency Ratio Variation

3.3 *SPECIAL PRIORITIES FOR NSPS*

Using the previously described prioritization methodology, a ranking of source categories can be developed subject to the 9 factors outlined: Model IV projections, control technology, emission measurement technology, enforceability, individual source impact, energy impact, scarce resource impact, other environmental media impact, and other considerations. The promulgation of New Source Performance Standards, however, is only one of a number of management mechanisms, and as such is subject to other demands and requirements that do not fit into the classification schemes outlined in the methodology. Considerations may arise that dictate the promulgation of a standard for a specific source category irrespective of its position in the ranking. As a flexible control program, NSPS promulgation must be able to respond to these considerations and adjust the allocation of resources accordingly. The emission projection procedure will provide an assessment of what emission penalties must be paid to change the priority schedule.

The identification of special priorities for NSPS is an exercise in planning and resource allocation that should be carried out at a level where total environmental control perspectives can be maintained.

The purpose of this section is to review those priority "areas of emphasis" that will influence the NSPS ranking process independently of any screening technique that can be applied. The first factor on the standard industrial evaluation form (Fig. 3-1), "Special Priority," is used to identify sources that fall into one of these areas.

Selection of special priority issues was made upon review of EPA internal memoranda and published work,[5] which were designed to identify problem areas. A recent study[6] completed by Argonne into forecasting new air pollution problem areas was used to expand the list. Issues were classified as pollutant priorities or strategy priorities.

3.3.1 *Pollutant Priorities*

Nitrogen Oxides and Hydrocarbons

The control of nitrogen oxides and hydrocarbons has been identified as one of the principle objectives of NSPS.[5] Both pollutants participate in photochemical oxidant formation and the state of the art of source-receptor dispersion modeling is crude in this case. Lacking an analytical tool that can be used to develop alternative control strategies, the application of best available control technology through NSPS may be the most viable way to proceed.

The additional complication of mobile source emission contributions puts further emphasis on the NSPS control program. Proposed amendments to the Clean Air Act[7] suggest relaxation of the stringent NO_x exhaust emission regulations for automobiles with added emphasis to be placed on stationary source controls. Although the following analysis will show that NO_x emission reduction over the 1975-1990 time period is not possible with even maximum application of NSPS, a vigorous program of stationary source controls is necessary to minimize the emission increases.

Sulfates

Recent studies[54] have indicated that sulfates are a potentially hazardous component of atmospheric pollution. As with HC and NO_x, the state of the art of dispersion modeling for this pollutant is undeveloped. Likewise, the body of knowledge on the dose-response of various susceptible portions of the population is limited. A significant research effort is currently under way under EPA sponsorship to identify the potential problems more definitely.

Control of sulfates through NSPS regulation of sulfur compound emissions appears to be the most efficient way to proceed, given the current state of knowledge. This will, nevertheless, be an exceedingly complex task due to the national energy situation. Control of sulfur compound emissions has a marked effect on fuel requirements, since fuel switching is one of the most effective methods of control. The same difficulties as have been encountered with the control of SO_2 can be expected in an attempt to control total sulfur compounds.

Fine Particulates

Submicron-size particulates are potentially the most hazardous because of their deep penetration into the respiratory system. The development of an ambient air quality standard for fine particulates is difficult because of the uncertainties of atmospheric reaction processes (such as aerosol formation) and the relationship of ambient concentrations to source emission characteristics.

Trace Metals

As with sulfates and fine particulates, the effects of trace metals (e.g., lead, manganese, chromium, vanadium, etc.) as atmospheric pollutants are receiving ever increasing attention. Interest in them is heightened by recent findings that some species tend to have a strong affinity for fine particulates and, therefore, are transported into the respiratory system where their potential health effects are maximized. The setting of an ambient air quality standard for all trace metals would be a monumental task and would consume an extremely large resource of money and manpower to enforce. NSPS appear to be the logical alternative, although the hazardous pollutant regulations (Section 112 of the Clean Air Act) may prove preferable for certain species.

Other Noncriteria Pollutants

Several other noncriteria pollutants have been evaluated as being candidates for an NSPS control program. Included are fluorides, acid mist, benzo (a) pyrene, and odors. Control of these pollutants under Section 111(d) of the Clean Air Act would mean that NSPS and the application of some existing source retrofit standard would comprise the entire control program. There are obvious advantages in simplicity and resource conservation in this approach and its use was studied in another program at Argonne under EPA sponsorship.[21] Fluoride and acid mist control has already been initiated under the NSPS program.

3.3.2 Strategy Priorities

Nondegradation Source Control

Recently promulgated regulations[8] for the prevention of significant air quality deterioration in areas currently below secondary NAAQS are aimed at providing controls on sources of SO_2 and particulates that, by the location of a single facility, are capable of presenting substantial problems in standard attainment. Since the facilities considered for control are exclusively new plants, the NSPS program is a vital portion of the regulatory effort. By ensuring application of best-available control technology, the source impacts can be minimized.

Air Quality Maintenance Planning (AQMP)

Substantial planning efforts are underway for the development of programs designed to demonstrate maintenance of the NAAQS over the ten-year period of 1975-1985. The development of control strategies is heavily dependent on NSPS as an indication of what level of emission control can be expected in newly developed industrial areas. Since the AQMP process relies on NSPS controls, the promulgation of standards for pollutants that are involved is a special need. Air quality maintenance area designations number 159 for particulates, 61 for SO_2, and 49 for oxidants. For CO, 24 have been proposed and for NO_2, 5.[9,10] Control of the oxidant problem depends on HC and NO_x controls; therefore, the AQMP process creates demand for NSPS for all criteria pollutants.

Augmentation of NAAQS Attainment Strategies

Many areas of the country are experiencing considerable difficulty in attaining the primary NAAQS. Particulates appear to be a widespread problem because of the complicating features of high-background levels, fugitive dust sources, and a large number of difficult-to-control sources. Oxidants and sulfur oxides are also presenting problems, but not as widespread. The use of NSPS to augment the air quality management strategies is a necessary feature of the overall control program.

Air Quality and Energy Relationships

The current national energy situation may result in some reorientation of the NSPS program in the interest of energy conservation. An initial consideration might be the postponement of NSPS that require significant increases in energy consumption (e.g., the use of an afterburner requiring natural gas as additional fuel). Another possibility is the acceleration of standard promulgation for sources that would experience energy conservation as a result of NSPS (e.g., petroleum handling loss reduction, use of self-sustaining afterburners for heat recovery).

Emerging Industries

The development of new industrial processes presents a unique opportunity to integrate air pollution control into the early stages of system design rather than including it as an afterthought. Industries such as coal gasification, refuse boilers for heat recovery, gas turbines used for electricity generation, and others are in the high-growth-rate stages and substantial benefits are to be had by developing uniform emission control requirements in these initial periods.

Integration of Environmental Control Programs

One criticism often leveled at the national environmental control program is that it is fragmented to the point of one effort contradicting or conflicting with another. This is a special problem when different environmental media (i.e., air, water, solid waste) are concerned. There is a need to coordinate the regulatory efforts of all programs into a unified, consistent process. For the NSPS effort, this means conducting standard development studies in parallel with efforts in water pollution control, solid-waste management, and/or hazardous material handling.

4. STANDARD SETTING PROGRAM ALTERNATIVES

4.1 EVALUATION PROCEDURE

The combination of the Model IV data, the source-screening methodology, the emission projections, and the priority areas of emphasis can be used to evaluate alternative NSPS programs. The method used here proceeds by reviewing alternative standard-setting programs for each pollutant, evaluating the impact of a combined pollutant control program, and determining the effects of special priorities.

In the individual pollutant analyses, the limits of NSPS control potential are determined from the emission projection model. Emission estimates under four conditions serve as bounds to the problem. First, it is assumed that no NSPS are set and the projected growth in each industrial category is controlled by State Implementation Plan regulations only. The analysis shows that emissions of every pollutant will increase markedly over the 1975-1990 time period. Second, only existing NSPS are assumed to be in effect and the emission projections are recomputed. This gives an indication of what portion of the control potential has been realized by previous work. Third, the maximum control potential is determined by assuming all standards, with the exception of those for source categories that lack a control technology, are set immediately. Although this is not realizable in practice, it does serve as a lower bound on emissions. Fourth, a nominal standard-setting pace is assumed, and the order in which the standards are set is assumed to be determined strictly by the Ts-Tn ranking. Given the limits established by these four conditions, it is possible to evaluate the effectiveness of program alternatives.

The next step in the individual pollutant analysis is to conduct the source-screening review to identify factors that would alter the source category ranking from that dictated by Ts-Tn order. Alternative strategies, wherein constraints are applied or ralaxed in turn, can be evaluated for their impact on emissions. The selection of the most desirable strategy is based on maximizing emission reductions within the limits of the constraining conditions.

The combined pollutant analysis uses the results of the individual pollutant reviews to fix the order in which standards are set for any one pollutant. It then investigates the effects of emphasizing one pollutant over another and evaluates the effects of programmatic decisions, such as standard-setting rate, delays between new and revised NSPS, and others.

Finally, the special priority analysis determines the effects of external factors, which change the previously determined order of source categories, and which alter the control potential achievable.

The choice of a 1975-1990 planning horizon is, to some extent, an arbitrary selection. The Model IV data developed by TRC[4] was designed to cover the period through 1985. This was extended to 1990 in this study to allow sufficient time for all standards to be set. Extension beyond 1990 was deemed unnecessary, since once all standards are set the relative differences between priority strategies remains constant.

For convenience, the emissions in 1975 are given on Table 4-1. These are constant and independent of the NSPS program alternative chosen. Emissions from EPA's National Emission Data System (NEDS) 1972 file[12] are also included for reference. The apparent discrepancies between the Model IV data and the NEDS data result from the different approaches. The NEDS file is based on an actual emission inventory of existing sources. The Model IV data are generalized estimates based on nationally averaged information. Given these two widely differing procedures, the comparisons are reasonably consistent.

Table 4-1. Comparative Emission Rates

	Emissions, 10^6 tons/year					
	1975 Model IV Data			1972 NEDS Data		
Pollutant	Stationary Sources	Mobile Sources[a]	Total	Stationary Sources	Mobile Sources	Total
Particulates	10.40	0.55	10.95	17.79	0.77	18.56
SO_2	31.10	0.53	31.63	31.40	0.62	32.02
NO_x	11.14	8.85	19.99	15.33	8.72	24.05
HC	14.41	12.49	26.90	10.35	16.28	26.63
CO	39.36	64.30	103.66	24.27	77.42	101.69

[a] Details of computation given in Appendix A.

4.2 *POLLUTANT PRIORITY ANALYSIS - PARTICULATES*

The emission projections that form the basis for evaluating NSPS needs and priorities for stationary sources of particulates are summarized in Fig. 4-1. Curve 1 shows the increase in emissions with no NSPS in effect and sources controlled by state regulations only (including state standards for new sources, $E_{s\ new}$ in Eqns. 3-7 and 3-8). The 1990 emissions are more than 59% higher than 1975 levels. Curve 2 illustrates that a substantial reduction in projected 1990 particulate emissions has already been achieved by the previously promulgated NSPS (including state new source standards), but that the achieved reduction is not sufficient to maintain future emissions below 1975 levels. An increase of more than 18% is calculated. A reduction of 23% below 1975 levels could, however, be achieved by setting all possible standards in 1975, as shown by Curve 3. The emissions projections from these two cases, i.e., existing NSPS only and all possible standards set in 1975, represent the bounds within which future emissions will lie.

The first-order prioritization is that based strictly on Ts-Tn values from Model IV calculations. Using this procedure (excluding categories for which no control technology exists) and assuming a nominal standard-setting rate of 6 particulate standards per year, emission projections below 1975 levels are achieved, as shown by Curve 4. Only a small change from the maximum control case is evident. The final particulate prioritization that considers additional factors is shown by Curve 5. The basis for this final prioritization is discussed later.

Using the source-screening methodology of Section 3, sources of particulate emissions were separated into seven groups with similar constraints or restrictions to NSPS promulgation. These were moved to a lower priority and the impact of the reordering on emission projections was evaluated. Following the regrouping, perturbations and adjustments were made to the ranking to obtain the final particulate priority ranking. Categories included in each constraint group are listed in Tables 4-2a through 4-2g.

Existing NSPS (ES)

Particulate NSPS have been promulgated or proposed for the 11 categories or subcategories indicated by an ES flag in Table 4-2a. For most of the categories given on the table, the primary restriction on setting a revised NSPS is the need to analyze data from sources subject to the initial NSPS and

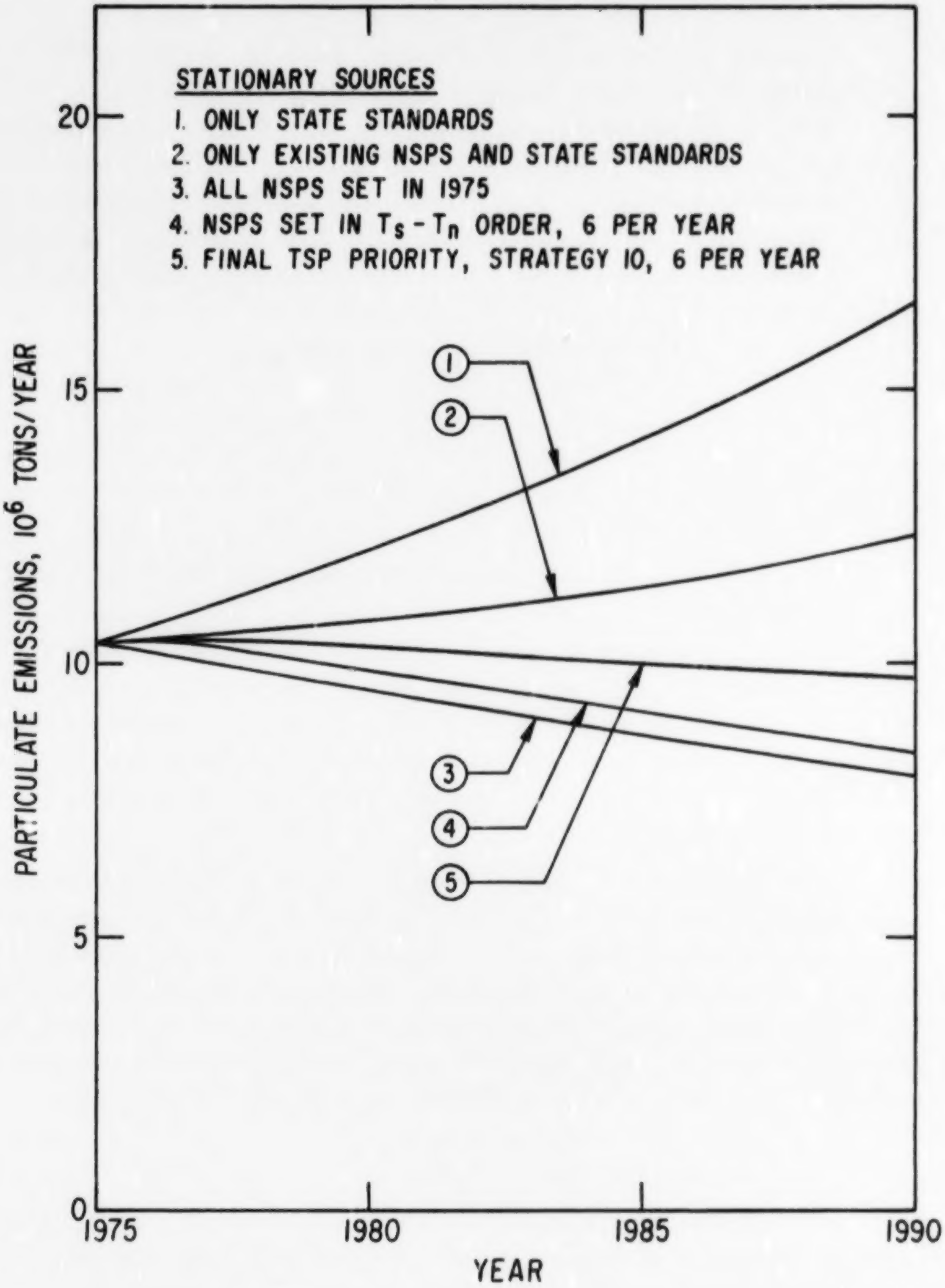

Fig. 4-1. Particulate Emission Projections for Stationary Sources

Table 4-2a. Particulate Source Categories with Existing NSPS (Group ES)

Category	Ts-Tn, 1985 (tons/year)	Ts-Tn Rank	Constraint and Priority Flags[a]
Boilers ($>250 \times 10^6$ Btu/hr)	490,000[b]	1[b]	
Asphalt Batching	25,000[b]	17[b]	
Iron and Steel Plants (Electric Arc Furnaces)	8,700[b]	30[b]	
Cement Plants (Kolns, Clinker Coolers)	5,200[b]	42[b]	3-RD[c]
Petroleum Refinery (FCCU)	3,800[b]	49[b]	
Municipal Incinerators	3,700[b]	50[b]	3-RD[c]
Brass and Bronze Smelters	50[b]	96[b]	3-RD[c]
Secondary Lead (Reverberatory Furnaces)	30[b]	97[b]	3-RD[c]
Secondary Lead (Blast Furnaces)	6[b]	101[b]	7-2, 9-0
Sludge Incineration	N/A[d]	N/A[d]	
Iron and Steel Plants (BOF)	N/A[d]	N/A[d]	

[a] First number is the factor considered, second character is the flag. Definition of flags is given in Section 3.2.2.

[b] Based on the promulgation of a revised NSPS.

[c] These sources have additional major constraints on the promulgation of a revised standard (i.e., additional research and development is required).

[d] Not applicable since these sources are not candidates for a revised NSPS; i.e., the present NSPS is felt to represent the best control technology.

Table 4-2b. Particulate Source Categories with No Major Constraints to Promulgation of NSPS (Group UN)

Category	Ts-Tn, 1985 (tons/year)	Ts-Tn Rank	Constraint and Priority Flags[a]
Boilers (10-250x10^6 Btu/hr)	420,581	3	
Grain Handling (Processing)	111,000	4	3-HC,[b] 5-EQ,[b] 10-U
Stone Quarrying and Processing	91,100	5	3-U, 5-EQ[b]/U
Grain Handling (Transfer)	90,700	6	3-HC,[b] 5-EQ,[b] 10-U
Industrial/Commercial Incineration	88,450	7	3-HC,[b] 5-EQ[b]
Grain Handling (Screening, Cleaning)	80,800	8	3-HC,[b] 5-EQ[b], 10-U
Boilers (Wood Waste)	80,800	9	3-U
By-Product Coke Ovens	59,600	12	6-FL
Lime Manufacture	42,500	13	3-HC,[b] 10-0
Steel Foundries (Secondary)	27,900	14	3-HC[b]
Cast Iron Foundry (Electric Furnace)	27,500	15	3-HC[b]
Primary Copper	26,400	16	
Wood Processing (Plywood)	22,600	18	3-U
Sand and Gravel Processing	21,700	19	3-U, 5-EQ[b]/U
Primary Aluminum Smelters	15,700	22	
Whiskey	14,600	23	
Vegetable Oil Manufacture	13,200	24	3-U
Mixed Fuel Boilers (Coal and Refuse)	10,500	26	6-FL, 9-0
Phosphate Rock (Grinding)	10,500	27	3-HC[b]

Table 4-2b. (Contd.)

Category	Ts-Tn, 1985 (tons/year)	Ts-Tn Rank	Constraint and Priority Flags[a]
Concrete Batching	9,680	29	5-EQ[b]
Nitrate Fertilizer	7,900	31	
Coal Cleaning (Thermal Drying)	7,500	32	
Grain Handling (Drying)	7,400	33	3-U, 5-EQ[b]
Beer Processing	7,300	34	
Feed Milling	7,300	35	3-HC[b]
Deep Fat Frying	6,000	38	3-RD,[b] 5-EQ,[b] 9-0
Ferroalloy	5,600	39	
Synthetic Resins	5,540	40	
Charcoal	5,300	41	
Polypropylene	5,100	43	6-FL
Sodium Carbonate (Natural)	4,950	44	
Cotton Ginning	4,800	45	9-0
Geramic Clay	4,100	46	3-U, 5-U
Synthetic Fiber (Dacron)	3,850	47	3-U, 9-0
Polyvinyl Chloride	3,600	51	9-0
Gypsum	2,700	53	
Iron and Steel Plants (Scarfing)	2,400	57	3-U, 6-FL
Paint Manufacture	2,000	60	
Secondary Aluminum (Reverberatory Furnace)	1,900	61	9-0

Table 4-2b. (Contd.)

Category	Ts-Tn, 1985 (tons/year)	Ts-Tn Rank	Constraint and Priority Flags[a]
Secondary Copper (Smelting)	1,900	62	
Secondary Copper (Handling)	1,400	63	3-U
Synthetic Fiber (Nylon)	1,320	64	3-U, 9-0
Feed Mill - Alfalfa Dehydrating	1,300	65	3-HC[b]
Lead Acid Battery Assembly	1,000	69	9-0
Flyash Sintering	990	70	
Frit	940	71	3-U, 9-0
Phosphoric Acid (Thermal Process)	721	72	9-0
Wood Processing (Pulpboard)	700	73	3-U
Perlite	610	76	
Carbon Black (Furnace Process)	500	78	
Secondary Aluminum (Sweat Furnace)	460	81	
Clay Sintering	420	82	
Mining and Milling of Lead Ore	297	83	
Explosives (High)	290	84	3-U
Primary Lead Smelters	250	86	9-0
Primary Zinc Smelters	240	87	
Secondary Zinc (Sweating)	196	88	
Meat Smokehouses	170	89	
Animal Feed Defluorination	160	90	3-U, 6-FL, 9-0

Table 4-2b. (Contd.)

Category	Ts-Tn, 1985 (tons/year)	Ts-Tn Rank	Constraint and Priority Flags[a]
Styrene Butadene Rubber	130	91	3-U
Secondary Zinc (Distillation)	129	92	
Secondary Lead (Pot Furnace)	20	99	
Secondary Magnesium Smelting	20	100	3-U
Fish Meal Processing	4	102	3-HC[b]

[a] Definition of flags is given in Section 3.2.2.

[b] Constraint is removed by subcategorization of source.

Table 4-2c. Particulate Source Categories Requiring Control Systems with Moderate Constraint Rating due to Increased Energy Consumption (Group MCR)

Category	Ts-Tn, 1985 (tons/year)	Ts-Tn Rank	Constraint and Priority Flags[a]
Brick and Related Clay Products	12,400	25	7-2, 8-0
Ammonium Sulfate Fertilizer	9,900	28	7-2
Iron and Steel Plants (Sintering)	6,200	37	7-2
Phosphate Rock (Drying)	3,800	48	7-2
Diammonium Phosphate Fertilizer	2,600	54	7-2
Sugar Cane (Bagasse Burning)	2,600	55	7-2
Asphalt Roofing (Saturator)	2,400	56	7-2, 9-0
Starch Manufacturing	2,300	58	7-2
Petroleum Refinery (Process Gas Combustion)	1,300	66	3-U, 7-2
Asphalt Roofing (Blowing)	1,100	67	7-2, 9-0
Mineral Wool	1,100	68	7-2
Phosphate Rock (Calcining)	630	75	7-2
Auto Body Incineration	600	77	7-2, 9-0
Detergent	490	79	3-U, 7-2
Granulated Triple Super-Phosphate Fertilizer (Storage)	470	80	7-2
Coffee Roasting	90	93	7-2, 9-0
Castable Refractory	90	94	3-U, 7-2
Soap Manufacturing	80	95	7-2

[a] Definition of flags is given in Section 3.2.2.

Table 4-2d. Particulate Source Categories for Which an Equipment Standard is Preferable (Group EQ)

Category	Ts-Tn, 1985 (tons/year)	Ts-Tn Rank	Constraint and Priority Flags[a]
Direct Firing of Meats	19,500	20	6-WS, 9-0, 10-U
Pathological Incinerators	29	98	5-LE, 9-0

[a] Definition of flags is given in Section 3.2.2.

Table 4-2e. Particulate Source Categories Requiring Fuel Switching to Achieve NSPS (Group FS)

Category	Ts-Tn, 1985 (tons/year)	Ts-Tn Rank	Constraint and Priority Flags[a]
Boilers ($0.3-10x10^6$ Btu/hr)	597,000	1	5-EQ, 7-3, 9-0
Boilers ($<0.3x10^6$ Btu/hr)	76,300	10	5-EQ, 7-3, 9-0
Stationary Gas Turbines[b]			
Electric Utility	64,500	11	5-EQ, 7-3, 9-0
Pipeline	3,600	52	5-EQ, 7-3, 9-0
Internal Combustion Engines (Diesel and Dual Fuel)	2,000	59	5-EQ/LE, 7-3

[a] Definition of flags is given in Section 3.2.2.

[b] These sources are treated together.

Table 4-2f. Particulate Source Categories Requiring Control Technology Research and Development Prior to NSPS Promulgation (Group RD)

Category	Ts-Tn, 1985 (tons/year)	Ts-Tn Rank	Constraint and Priority Flags[a]
Glass Production (Soda Lime)	15,700	21	
Mixed Fuel Boilers (Oil and Refuse)	7,200	36	6-FL/LO
Fiberglass (Textile Processing)	670	74	
Glass Manufacturing (Opal Glass)	250	85	9-0

[a] Definition of flags is given in Section 3.2.2.

Table 4-2g. Particulate Source Categories for Which There Is No Control Technology Available (Group NC)

Category	Ts-Tn, 1985 (tons/year)	Ts-Tn Rank	Constraint and Priority Flags[a]
Open Burning (Agricultural)	2,603,100[b]	N/A	5-LE
Sugar Cane (Field Burning)	84,000[b]	N/A	5-LE
Hydrofluoric Acid	0	N/A	7-2
Fiberglass Production (Wool Processing)	0	N/A	
Iron and Steel Plants (Blast Furnace)	0	N/A	
Wood Pulping (Kraft)	0	N/A	
Wood Pulping (Sulfite)	0	N/A	
Orchard Heaters	0	N/A	

[a] Definition of flags is given in Section 3.2.2.

[b] Based on an assumed value of $E_n = 0$.

evaluate the practical feasibility of making the limits stricter. Given the rate at which this information could be assembled and the rate at which the mechanics of revising the standard could be completed, it appears that five years is a reasonable estimate of the delay time between the promulgation of the original NSPS and the promulgation of a revised standard. Therefore, in this analysis, the setting of the revised NSPS for these sources is subject to a five-year lag time. Other than this consideration, the sources are included in their respective groups in Ts-Tn order. Should the standard-setting strategy selected reach these sources prior to the elapse of the five-year period, they will be passed over and standards will be set at the end of the five years. Should the strategy reach these sources later than the five years, the standards will be set in normal Ts-Tn order.

For the cement plants (kilns and clinker coolers), municipal incinerators, and brass and bronze smelters, revised standards would require additional research and development. Since these constraints are more severe than the procedural constraint of revising a standard, these categories were also treated with the RD group discussed below.

The sludge incineration and basic oxygen furnaces at iron and steel plants were not considered for revised NSPS since the current standard is felt to reflect the best control technology for these sources. In addition to the existing particulate NSPS shown here, standards for the primary zinc, primary lead, ferroalloy, and coal cleaning categories have recently been promulgated. At the time the TRC data were assembled it was decided to ignore the proposed standards since the final disposition was uncertain. For consistency's sake, these recent promulgations and proposals are also ignored here. All of these categories fall in the Unconstrained Group described below.

Unconstrained (UN)

The group without any major restrictions to the establishment of NSPS contains 64 source categories (Table 4-2b). The boiler ($10\text{-}250\text{x}10^6$ Btu/hr) category rated highest in Ts-Tn value for this group and would thus be given the highest priority in the final prioritization of particulate sources. Assuming an average size of $100\text{x}10^6$ Btu/hr, over 14,000 new sources in this category will be constructed by 1990.[4] A NSPS of 0.127 lb/10^6, compared to the existing state regulations, would result in an emission reduction of 635,000 tons/year in 1990. The enforcement effort for this number of sources would be large, but not prohibitive, in view of the reduction possible. The cost per pound of pollutant removed could be somewhat larger than for the units $>250\text{x}10^6$ Btu/hr, but again should not be prohibitive. The grain handling (processing and handling) were the second and fourth categories in this grouping; however, a high level of uncertainty (indicated by the "U" flag) in the actual reduction achievable remains because of the diverse nature of this industry and the level of emissions emanating from uncontrollable fugitive sources. Similar comments relate to the sand, stone, and gravel industries that ranked high in this group. In addition to this high ranking, there is an incentive to promulgate NSPS for the lime category because of its similarity to the portland cement category for which there is existing NSPS.

The recently promulgated standards for primary zinc, primary lead, coal cleaning, and ferroalloy were not considered in these data.

Moderate Constraint Ratings (MCR)

The most viable method of attaining the indicated reduction in emissions for this group (Table 4-2c) is through application of scrubbers or afterburners. The energy consumption of these devices in comparison to baghouse or ESP's was the basis for placement of the categories into a separate group. The highest ranking category in this group, brick and related clay products, was ranked only number 25, based on Ts-Tn value.

Equipment Standard Preferable (EQ)

The two categories, pathological incinerators and direct firing of meats, in Table 4-2d consist primarily of numerous small units and the only practical means of enforcing NSPS is to require an equipment standard. Questions as to the validity of equipment standards under Section 111 places a constraint on NSPS promulgation for these categories. Consideration of public demand for control of pathological incinerators for esthetic reasons may, however, indicate a higher priority for this category.

Fuel Switching Required (FS)

With the exception of moderate size boilers (see UN group) further reduction in particulate emissions for boilers and other fuel combustion sources in Table 4-2e is only achievable in the 1975-1990 period through fuel switching. The low availability of necessary fuels thus places a severe constraint on further standard promulgation for these sources. Removal of this group from the Ts-Tn ordering had the largest single impact on projected emissions and should therefore be subject of continuing evaluation to determine applicability of new technology or increased availability of required fuels. The stationary gas turbines are treated together with the following effort:

Category	Normalized Standard Development Effort
Stationary Gas Turbines	
Electric Utility	0.5
Pipeline	0.5

Research and Development Required (RD)

Categories in this group (Table 4-2f) cannot achieve the indicated emissions reduction without applying advanced control technology or process changes that have not been fully developed. For the mixed fuel boilers (oil and refuse) category, it may be necessary to promulgate standards to provide uniform control for the emerging industry; however, significant reduction below current levels, which are equivalent to NSPS for utility boilers, is not expected.

The availability of control technology was based in part on the first-order approximation that emissions could be controlled to a level of 0.01 grains/standard cubic ft. exhaust gas concentration with current technology, unless specific contrary information was available. This level approximates that for existing NSPS.

No Demonstrated Control Technology Available (NC)

The open burning (agriculture and sugar cane) categories are the largest emitters in this group in Table 4-2g; however, Section 111 of the Clean Air Act in its present form would be difficult to apply to these categories.

An evaluation of the effect of imposing the above constraints on the priority ranking is summarized in Table 4-3. The first four strategies correspond to Curves 1-4 in Fig. 4-1. In Strategy 5, the RD constraint group was delayed with only minor impact on emission projections in comparison to Strategy 4 with standards set in strict Ts-Tn order. On the other hand, delay of the group requiring fuel switching (FS) in Strategy 6 had the largest single impact on projected emissions of any constraint group, increasing the 1990 projected emissions from -17.3% to -6.7% below 1975 values and decreasing the efficiency ratio to 60.5%.

Delaying the moderate constraint rating group (MCR) in Strategy 7 and the equipment standards (EQ) in Strategy 9 also had only a minor impact on projected emissions.

Strategy 9 represents the case when all constraint groups are postponed. The emissions projections remain below 1975 levels except for a small increase in 1976 before sufficient additional standards are promulgated.

In Strategy 8 the single category of moderate size steam generators ($10-250 \times 10^6$ Btu/hr) was removed from the unconstrained (UN) to the fuel switching (FS) groups. The result was a significant increase in projected 1990 emissions that exceeded 1975 levels, clearly illustrating the importance of placing NSPS development for this category in high priority.

Because of the large number of sources in the unconstrained group (64), setting all standards in this group as a first priority results in a longer-than-warranted delay of standard setting for the subsequent group (MCR), which requires energy consuming scrubbers or afterburners. As an alternative, in Strategy 10 only the categories in the unconstrained group with 1985 Ts-Tn values greater than 3000 tons/year were kept in the high priority ranking and the remainder of the unconstrained group were combined with the subsequent group in an order based on Ts-Tn values. This strategy was considered the baseline prioritization for particulate categories for use in the simultaneous consideration of all pollutants as discussed in Section 4.7. In Strategy 10, the setting of standards for the group requiring fuel switching is not initiated until 1990 at the standard setting rate of 6 per year.

The effect of alternate rates of 4 and 10 per year for particulate standards is illustrated by Strategies 11 and 12. The large impact of

Table 4-3. Particulates Priority Strategy Summary[a]

Priority Strategy[b,c]	Standard Setting Rate (no./yr)	Maximum Emission Rate (10^6 tpy)	Maximum Emission Rate (yr)	1985 Emissions (10^6 tpy)	1985 % Change from 1975	1990 Emissions (10^6 tpy)	1990 % Change from 1975	Efficiency Ratio (%)[d]
1. State standards only		16.56	1990	14.08	+35.4	16.56	+59.3	-97.0
2. Only existing NSPS and state standards		12.34	1990	11.46	+10.2	12.34	18.6	0.0
3. All NSPS set in 1975		10.40	1975	8.72	-16.2	7.99	-23.2	100.0
4. NSPS set in Ts-Tn order	6	10.43	1975	9.12	-12.3	8.39	-19.3	90.7
5. Postpone RD group (UN/RD)	6	10.43	1975	9.31	-10.5	8.60	-17.3	85.9
6. Postpone FS and RD groups (UN/FS/RD)	6	10.45	1976	9.97	- 4.1	9.71	- 6.7	60.5
7. Postpone MCR, FS, RD groups (UN/MCR/FS/RD)	6	10.45	1976	9.99	- 3.9	9.73	- 6.4	59.9
8. Same as 7 with boilers (10-250x10^6 Btu/hr) in FS group (UN/MCR/FS/RD)	6	10.52	1980	10.37	- 0.3	10.33	- 0.7	46.2
9. Postpone all constraint groups (UN/MCR/EQ/FS/RD)	6	10.45	1976	10.00	- 3.8	9.75	- 6.2	59.4
10. Same as 9 with UN sources less than 3000 tpy delayed with MCR group (UN^e/MCR^f/EQ/FS/RD)	6	10.45	1976	9.99	- 3.9	9.73	- 6.4	59.9
11. Same as 10	4	10.46	1977	10.08	- 3.1	9.84	- 5.4	57.5
12. Same as 10	10	10.44	1976	9.86	- 5.1	9.13	-12.2	73.6
13. Same as 12 with FS and RD excluded	10	10.44	1976	9.99	- 4.7	9.63	- 7.3	62.2
14. Postpone revised NSPS (UN^e/MCR^f/EQ/FS/RD/ES (revised))	6	10.45	1976	10.27	- 1.3	10.29	- 1.0	47.0

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[a] Stationary sources only.

[b] All strategies exclude standards for group with no demonstrated control technology (NC). The unconstrained (UN) group includes all sources in Ts-Tn order unless a specific constraint is involved.

[c] Except for Strategy 1, all strategies assume existing NSPS to be in effect in 1975. Except for Strategies 1-4, all revised NSPS are subject to at least a 5-year delay in addition to other constraints that may be involved in the revision.

[d] Computed from the formula $[(E_2-E_{strategy})/(E_2-E_3)]_{1990} \times 100\%$; i.e., Eqn 3-15 where E_2(Strategy 2) is E_{max} and E_3 (Strategy 3) is E_{min}.

[e] Only sources with Ts-Tn > 3000 tpy included.

[f] Unconstrained sources with Ts-Tn < 3000 tpy included.

increasing the rate to 10 per year is largely attributable to earlier initiation of standard setting for the group requiring fuel switching because of the large sources in this group. This is illustrated in Strategy 13 in which the standard setting rate is set at 10 per year but no standards for the fuel switching or RD group are promulgated.

Strategy 14 shows the impact of postponing the revision of an existing NSPS until all other standards have been set. This strategy results in the poorest emission picture except for Strategy 8. This indicates the importance of considering revisions for the large boiler category, which has the largest Ts-Tn potential.

For the particulate priority analysis, the generalized procedure that allows alternate relative manpower requirements for standard development was implemented. The following categories were assumed to require the indicated normalized standard development effort:

Category	Normalized Standard Development Effort
Grain Handling (Processing)	2
Grain Handling (Transfer)	0.5
Grain Handling (Screening, Cleaning)	0.5
Grain Handling (Drying)	0.5
Industrial/Commercial Incinerators	1.5
Ferroalloy (Arc Furnace)	2
Secondary Copper (Handling)	1.5

All other categories were assigned a development effort of 1.0.

The categories with greater than unity effort required are large and diverse and may necessitate multiple standards. On the other hand, the subsequent Grain Handling subcategories would require reduced standard development effort because of relevant background information compiled for the initial processing subcategory. The above deviations from normal development effort are not intended to be a precise or complete listing, but rather are included to emphasize that differences in required effort do exist. If estimates of the effort-required parameter were available for all source categories, the Ts-Tn ordering could be weighed by the inverse of the effort as discussed in Section 3.3.

The evaluation of achievement attributed to particulate NSPS can be deceiving if based on total emission mass only as is done in this analysis.

A more precise evaluation would include weighting of the impact of emissions based on size distribution of the particulates and their chemical composition. Current control techniques are less efficient for fine particulates and thus the percent reduction for these smaller particles may be significantly less than the overall reduction. Differences in chemical composition and their environmental impacts could be accounted for in a weighting scheme based on Threshold Limit Values, as was done in a recent EPA Industrial Emissions Research Laboratory Study.[55]

Particulate emissions from mobile ground level sources, as illustrated in Appendix A are not a major contributor and were thus not included in this analysis.

4.3 POLLUTANT PRIORITY ANALYSIS - SULFUR DIOXIDE

The potential for control of SO_2 emissions through the promulgation of NSPS is shown in Fig. 4-2. A substantial reduction of 26% in projected 1990 emissions is shown to have already been achieved by the NSPS for SO_2 currently in effect (Curve 2); however, this reduction is not large enough to prevent an increase over estimated 1975 emissions without development and promulgation of additional standards.

The mobile source emissions of SO_2, as computed in Appendix A, are relatively insignificant and were thus not included in the priority analysis.

Assuming the nominal standard setting rate for SO_2 sources of 4 NSPS per year (excluding sources with no demonstrated control technology) and priorities l strictly on Ts-Tn values, the projected emissions would decrease by over 40% from the 1975 levels (Curve 4), indicating that additional factors can be included in the prioritization without permitting significant increases in projected emissions. For the prioritization in view of additional factors, the sources of SO_2 emissions were grouped into six categories as shown in Table 4-4a to 4-4f and discussed below.

Existing NSPS (ES)

Sulfur dioxide standards have been proposed or promulgated for three categories: large steam generators, sulfuric acid plants, and petroleum refineries (Table 4-4a). For this analysis, all standards were assumed in

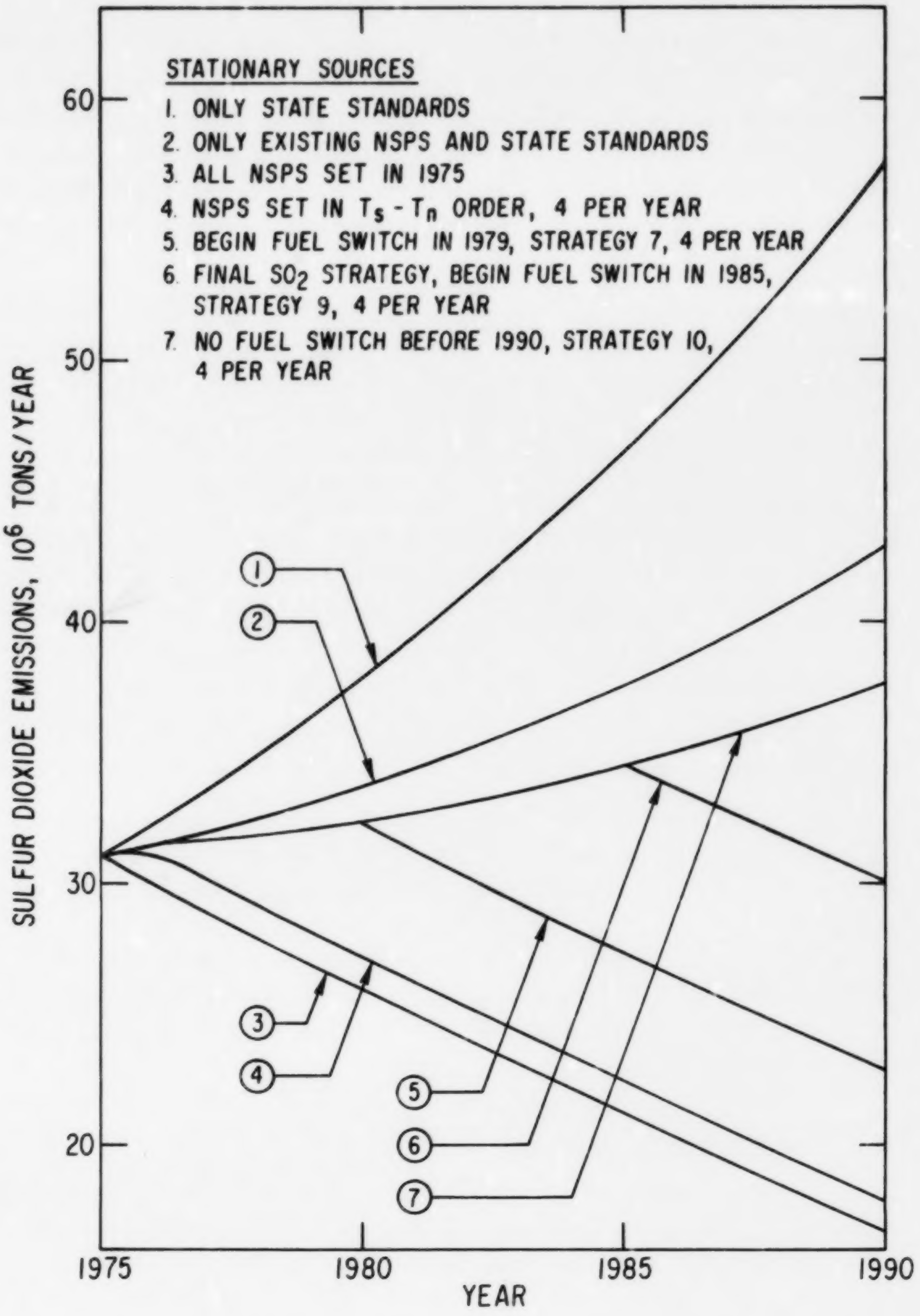

Fig. 4-2. Sulfur Dioxide Emission Projections for Stationary Sources

Table 4-4a. Sulfur Dioxide Source Categories with Existing NSPS (Group ES)

Category	Ts-Tn, 1985 (tons/year)	Ts-Tn Rank	Constraint and Priority Flags[a]
Boilers (>250x10^6 Btu/hr)	8,351,900[b]	1[b]	5-FS,[c] 7-3, 9-0
Sulfuric Acid	23,100[b]	17[b]	3-RD,[d] 7-2, 9-0/2[e]
Petroleum Refinery (Process Gas Combustion)	N/A[f]	N/A[f]	

[a] First number is the factor considered, second character is the flag. Definition of flags is given in Section 3.2.2.

[b] Based on the promulgation of a revised NSPS.

[c] This source has an additional major constraint on the promulgation of a revised standard (i.e., fuel switching required).

[d] This source has an additional major constraint on the promulgation of a revised standard (i.e., additional research needed).

[e] Scrubbers are used for control resulting in simultaneous reduction in particulates (9-0) with an increase in solid waste generation (9-2).

[f] Not applicable, since this source is not a candidate for a revised NSPS; i.e., the present NSPS is felt to represent the best control technology.

Table 4-4b. Sulfur Dioxide Source Categories with No Major Constraints to Promulgation of NSPS (Group UN)

Category	Ts-Tn, 1985 (tons/year)	Ts-Tn Rank	Constraint and Priority Flags[a]
Primary Copper Smelters[b]	1,740,000	3	6-FL, 7-2, 9-0/2[c]
Primary Zinc Smelters[b]	741,000	5	
Portland Cement (Kilns, Clinker Coolers)	334,900	6	3-U, 7-0, 9-0
Primary Lead Smelters[b]	177,000	8	6-FL, 7-2, 9-0/2[c]
Wood Pulping (NSSC)	110,000	11	3-U
Wood Pulping (Sulfite)	54,000	12	
Wood Pulping (Kraft)	10,600	19	9-0
Lime	9,400	22	3-U, 9-0
Fiberglass (Textile Manufacturing)	8,200	23	
Fiberglass (Wool Processing)	2,800	26	

[a] Definition of flags is given in Section 3.2.2.

[b] NSPS have now been promulgated for these sources.

[c] Scrubbers are used for control resulting in simultaneous reduction in particulates (9-0) with an increase in solid waste generation (9-2).

Table 4-4c. Sulfur Dioxide Source Categories Requiring Control Systems with Moderate Constraint Rating due to Energy Consumption (Group MCR)

Category	Ts-Tn, 1985 (tons/year)	Ts-Tn Rank	Constraint and Priority Flags[a]
Mixed Fuel Boilers (Coal and Refuse)	119,000	10	6-FL, 7-2, 9-0/2[b]
Explosives (High)	41,400	13	3-U, 7-2, 9-0/2[b]
Secondary Lead (Reverb Furnace)	29,600	15	3-U/HC, 7-2, 9-0/2[b]
Explosives (Low)	24,500	16	7-2, 9-0/2[b]
Refinery Fuel Gas (Sulfur Recovery)	17,500	18	7-2, 9-0
Sulfur Recovery (Crude Oil and Natural Gas Production)	9,900	21	3-U, 7-2, 9-0

[a] Definition of flags is given in Section 3.2.2.

[b] Scrubbers are used for control resulting in simultaneous reduction in particulates (9-0) with an increase in solid waste generation (9-2).

Table 4-4d. Sulfur Dioxide Source Categories Requiring Fuel Switching to Achieve NSPS (Group FS)

Category	Ts-Tn, 1985 (tons/year)	Ts-Tn Rank	Constraint and Priority Flags[a]
Boilers (10-250x10^6 Btu/hr)	2,566,300	2	7-3, 9-0
Boilers (.3-10x10^6 Btu/hr)	1,670,000	4	5-EQ, 7-3, 9-0
Boilers (<.3x10^6 Btu/hr)	209,000	7	5-EQ, 7-3, 9-0
Stationary Gas Turbines[b]			
Electric Utility	122,000	9	5-LE, 7-3
Pipeline	2,700	27	5-LE, 7-3
Coal Cleaning (Thermal Drying)	10,200	20	7-3, 9-0
Internal Combustion Engines (Diesel and Dual Fuel)	6,200	24	5-LE/EQ, 7-3, 9-0
Brick and Related Clay Products	5,500	25	7-3, 9-0
Asphalt Batching	2,300	28	7-3

[a] Definition of flags is given in Section 3.2.2.

[b] These sources are treated together.

Table 4-4e. Sulfur Dioxide Source Categories Requiring Control Technology Research and Development Prior to NSPS Promulgation (Group RD)

Category	Ts-Tn, 1985 (tons/year)	Ts-Tn Rank	Constraint and Priority Flags[a]
Mixed Fuel Boilers (Oil and Refuse)	29,600	14	3-U, 6-FL, 7-2, 9-0/2[b]
Secondary Lead (Blast Furnace)	1,400	29	3-HC/U, 7-2, 9-0/2[b]

[a] Definition of flags is given in Section 3.2.2.

[b] Scrubbers are used for control resulting in simultaneous reduction in particulates (9-0) with an increase in solid waste generation (9-2).

Table 4-4f. Sulfur Dioxide Source Categories for Which There Is No Control Technology Available (Group NC)

Category	Ts-Tn, 1985 (tons/year)[a]	Ts-Tn Rank	Constraint and Priority Flags[b]
Petroleum Refinery (FCCU)	259,000	N/A	9-0
Primary Aluminum Smelter	218,000	N/A	7-2
Iron and Steel Plant (Sintering)	53,600	N/A	3-U, 6-FL, 7-2, 9-0
Glass Production (Soda Lime Glass)	35,600	N/A	3-U
Industrial/Commercial Incinerators	32,870	N/A	
Municipal Incinerators	30,200	N/A	6-LO
Hyproduct Coke Oven	900	N/A	7-2
Orchard Heaters	680	N/A	5-EQ
Glass Production (Opal Glass)	510	N/A	3-U
Hydrofluoric Acid	432	N/A	
Mineral Wool	30	N/A	

[a] Based on an assumed value of $E_n = 0$.

[b] Definition of flags is given in Section 3.2.2.

effect in 1975. Revised standards for each of these groups was determined to be either not feasible, to require additional research and development, or to require fuel switching. Since these constraints are more severe than the procedural constraint of revising a standard, these categories were also treated with the NC, RD, or FS groups discussed below.

In addition to these existing SO_2 NSPS, standards have recently been promulgated for the primary copper, primary zinc and primary lead smelters. In a manner similar to that for particulates, these proposed standards were ignored in the TRC data collection because of the uncertainty of the final standard level. They are likewise ignored here. All of these sources are in the Unconstrained Group discussed below.

Unconstrained (UN)

Based on available information, categories in Table 4-4b have no significant constraints that would inhibit application of control technology required to meet NSPS. The indicated reduction in SO_2 emissions for the portland cement and lime categories can be achieved through design changes curtailing fuel consumption in the drying process. The resultant energy conservation is an added incentive for NSPS promulgation for these categories. The wood pulping categories achieve reduction in emissions by conversion to alternate chemical processes. Conversion to electric furnaces in fiberglass manufacturing is a demonstrated technology and thus eliminates the need for fossil-fueled furnaces, which are the primary source of SO_2 emissions in this industry.

The recently promulgated standards for the primary copper zinc, and lead smelters is not considered in these data.

Moderate Constraint Rating (MCR)

Categories in this group (Table 4-4c) generally require the use of scrubbers that are moderate consumers of energy. Scrubbing also has the disadvantage of producing solid/liquid wastes, although this environmental impact is partially offset by the benefit from simultaneous removal of particulates from the gas stream.

Fuel Switching Required (FS)

Included in this group (Table 4-4d) are all SO_2 source categories that could attain further SO_2 emission control primarily through switching to natural gas or other fuels with low sulfur content. The availability of these fuels presents a severe constraint on promulgation of NSPS. The four classes of boilers in this group (including a revised standard for boilers $>250\times10^6$ Btu/hr from the existing standards group on Table 4-4a) received the highest ranking of all categories based on Ts-Tn alone, which points out the importance of this group. For the smaller individual sources, cleaning of the stack gas with scrubbers may be technologically feasible but would be very costly without additional research and development. Further control beyond existing NSPS may be possible for the largest class of boilers in the near future without fuel switching as experience in scrubber operation is accumulated. Appreciable control could be obtained by selective application of fuel switching to certain facilities within a category in critical areas, but this option is not provided by Section 111 of the Clean Air Act.

The stationary gas turbine engines are treated together with the following normalized standard development effort:

Category	Normalized Standard Development Effort
Stationary Gas Turbine	
Electric Utility	0.5
Gas Pipeline	0.5

Research and Development Required (RD)

For this group of categories (Table 4-4e) stack gas scrubbing is the most viable technique for obtaining additional emission control; however, further improvements in technology are required in order for the reduction below present levels to be significant without excessive cost to the industry.

No Demonstrated Control Technology Available (NC)

The categories in this group (Table 4-4f) are not expected to be capable of achieving further emission control at a reasonable cost in the 1975-1990 time period. Included are categories for which there is no demonstrated control technology and the Ts-Tn values that are given assume zero emissions on new sources in order to show the impact of this lack of technology; the cumulative effect is about 632,000 tons/year (Ts-Tn, 1985).

The impact of prioritization of SO_2 source categories on the basis of the above groupings is summarized in Table 4-5. In all evaluations, NSPS for the NC group were assumed not to be promulgated in the period 1975-1990.

Categories requiring additional control research (RD group) were assumed to have lowest priority. Without changing other priorities, this perturbation (Strategy 5) resulted in a 10.7% increase in 1985 SO_2 emissions (compared to Strategy 4). (With the nominal standard setting rate of 4 SO_2 NSPS per year, standard setting for this low priority group is initiated in 1981.)

For the next perturbation from Ts-Tn ranking, the categories requiring fuel switching were moved to lower priority (Strategy 6) with a resultant major increase of 15% in 1990 emissions as compared to standard setting based only on Ts-Tn rank. Furthermore, annual emissions increase to a maximum of 4% over 1975 emissions, the maximum occurring in 1979 just before standard setting for the FS group is initiated.

Maintaining this prioritization in Strategy 7 with the exception that the MCR group categories (requiring control systems with moderate energy consumption) are ranked just below the unconstrained group results in approximately 0.1% increase in 1985 SO_2 emissions over Strategy 6 levels. Because of this small increase, the lowering of priority for this group can be maintained.

The above preliminary analysis clearly demonstrates the dilemma of the SO_2 standard setting prioritization. The setting of standards for boilers and other large consumers of fossil fuels is a dominant factor in the maintenance of 1975 emission levels using Section 111 mechanisms only, but the setting of these standards requires use of low-sulfur fuel, which is in low supply or alternatively requires the use of significantly advanced SO_2 stack gas scrubbers. The effect of delaying the FS group standards is further illustrated by curves 5, 6, and 7 in Fig. 4-2. The curves in this figure are based on 4 standards per year and ranking of groups as before, but with the addition of a further delay in initiation of standard setting for the third and fourth groups. The

Table 4-5. Sulfur Dioxide Priority Strategy Summary[a]

Priority Strategy[b,c]	Standard Setting Rate (no./yr)	Maximum Emission Rate		1985		1990		
		(10⁶ tpy)	(yr)	Emissions (10⁶ tpy)	% Change from 1975	Emissions (10⁶ tpy)	% Change from 1975	Efficiency Ratio (%)[d]
1. State standards only		57.69	1990	46.65	+50.0	57.69	+85.5	- 56.9
2. Only existing NSPS and state standards		42.84	1990	37.59	+20.9	42.84	+37.8	0.0
3. All NSPS set in 1975		31.10	1975	21.26	-31.6	16.72	-46.2	100.
4. NSPS set in Ts-Tn order	4	31.32	1975	22.47	-27.7	17.93	-42.3	95.4
5. Postpone RD group (UN/RD)	4	31.35	1976	25.81	-17.0	21.27	-31.6	82.6
6. Postpone FS, RD groups (UN/FS/RD)	4	32.25	1979	27.40	-11.9	22.86	-26.5	76.5
7. Postpone all constraint groups (UN/MCR/FS/RD)	4	32.27	1979	27.41	-11.8	22.87	-26.4	76.4
8. Delay FS, RD groups until 1982 (UN/MCR/FS/RD)	4	33.11	1982	30.38	- 2.3	25.84	-16.9	65.1
9. Delay FS, RD groups until 1985, final strategy (UN/MCR/FS/RD)	4	34.48	1985	34.48	+10.9	30.08	- 3.3	48.9
10. Delay FS, RD groups until after 1990 (UN/MCR/FS/RD)	4	37.83	1990	34.48	+10.9	37.83	+21.6	19.2

[a] Stationary sources only.

[b] All strategies exclude standards for group with no demonstrated control technology (NC). The unconstrained (UN) group includes all sources in Ts-Tn order unless a specific constraint is involved.

[c] Except for Strategy 1, all strategies assume existing NSPS to be in effect in 1975. Except for Strategies 1-4, all revised NSPS are subject to at least a 5-year delay in addition to other constraints that may be involved in the revision.

[d] Computed from the formula $[(E_2-E_{strategy})/(E_2-E_3)]_{1990}$ x 100%; i.e., Eqn. 3-15 where E_2 (Strategy 2) is E_{max} and E_3 (Strategy 3) is E_{min}.

peak emissions reach a maximum in 1990 or 122% of 1975 emissions (37.83 million tons/year) if the standards for these groups are not set at all in the 1975-1990 period (Strategy 10).

Strategy 9 is selected as the prioritization procedure for SO_2 (Curve 6 on Fig. 4-2). It is felt that 1985 is the earliest that clean fuels (e.g., low sulfur coal, gasified coal, etc.) or advanced flue gas desulfurization technology will be in adequate supply to warrant consideration of the NSPS that would require fuel switching or advanced technology. This may, in fact, prove to be optimistic and delays in the NSPS for these sources may have to be postponed until 1990 or later.

4.4 POLLUTANT PRIORITY ANALYSIS - NITROGEN OXIDES

Control of nitrogen oxide (NO_x) emissions is affected by mobile and stationary source influences. Figure 4-3 is the set of limit curves for stationary sources only. It is obvious that even under maximum NSPS control impact through the setting of all possible standards immediately (Curve 3), emissions still increase substantially over the 1975-1990 period. The 1990 emissions are 44.4% higher than the 1975 emissions, which is an increase of 5.0 million tons/year. This is a little less than half of the emission increase (Curve 1), which would result from not setting any NSPS.

NO_x standards have been promulgated for only two source categories to date: large boilers ($> 250 \times 10^6$ Btu/hr) and nitric acid plants. Curve 2 of the figure shows that these standards represent only a small portion of the NSPS control potential. In 1990, these two standards provide only a 4% reduction in emissions from the unregulated case.

Curve 4 shows the impact of setting the NSPS for NO_x in strict Ts-Tn order at the rate of 4 standards per year. The source categories for which there is no control technology available have been excluded. As with the other pollutants, this does not result in a substantial change from the maximum impact case of Curve 3, since the large sources are controlled very quickly.

Curve 5 gives the final prioritization and will be discussed later.

Figure 4-4 shows the combined emission rates of mobile and stationary sources. The mobile source calculations assume the most stringent NO_x emission standards for automobiles to go into effect in 1978. Details of the

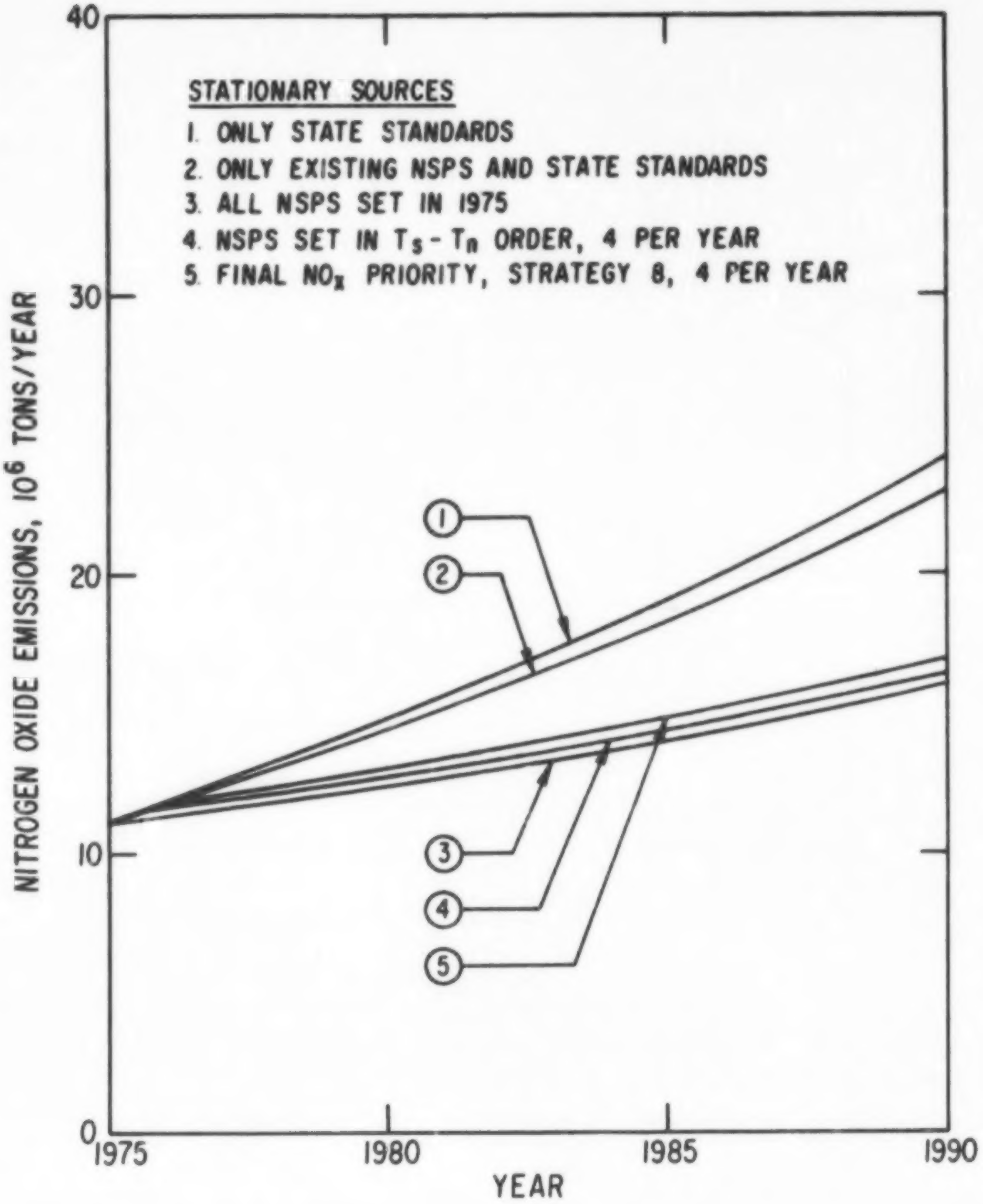

Fig. 4-3. Nitrogen Oxide Emission Projections for Stationary Sources

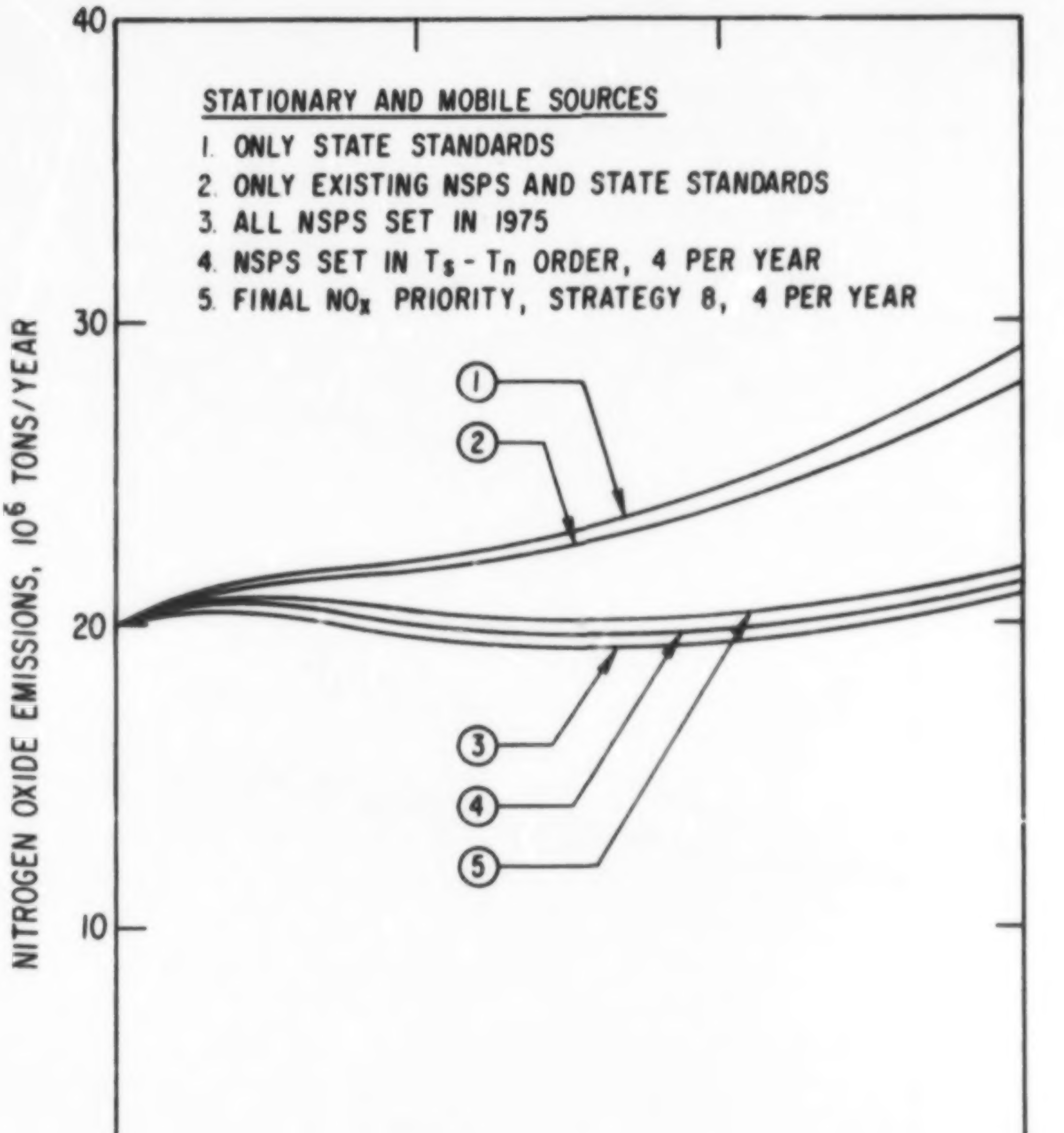

Fig. 4-4. Nitrogen Oxide Emission Projections for Stationary and Mobile Sources

calculation are given in Appendix A. The results on the figure are especially significant in light of the fact that one of the rationales used to argue for relaxation of the stringent emission controls on motor vehicles was that the same emission reductions could be achieved through the imposition of stricter stationary source controls. These data show that the growth characteristics of stationary sources and the availability of emission control technology are such that total emission rates will increase through 1990 despite the most rapid application of NSPS. Stated differently, stationary source NO_x emissions cannot be reduced in the 1975-1990 time frame even with the strictest application of NSPS and therefore cannot compensate for mobile source emission increases. Retrofit of existing sources has not been included in this consideration.

While the indications are that the imposition of source constraints on the standard setting procedure will compound an already difficult situation, some of the constraints are unavoidable and their effect will be evaluated here. Using the source screening methodology, the nitrogen oxide categories were separated into six groups as shown on Tables 4-6a to 4-6f.

Existing NSPS (ES)

As shown on Table 4-6a, this group contains the large boilers (>250 x 10^6 Btu/hr) and nitric acid plants. As with the other pollutants, the NSPS are assumed to be in effect in 1975. Based on the TRC review, these sources are also candidates for revised NSPS. For both the large boilers and the nitric acid plants, the setting of a revised NSPS is not constrained by any of the factors considered here. The available information[11] indicates that the boilers could achieve additional NO_x emission reductions through the application of a combination of design modifications (e.g., off-stoichiometric combustion, flue gas recirculation, tangential firing, etc.) instead of a single modification that could be used to meet the current standard. Some nitric acid plants have already demonstrated emission levels 33% below the current standard and, therefore, a revised standard is not inconceivable. The only restriction is the five-year time lag between original and revised standards as discussed previously.

Table 4-6a. Nitrogen Oxide Source Categories with Existing NSPS (Group ES)

Category	Ts-Tn, 1985 (tons/year)[a]	Ts-Tn Rank	Constraint and Priority Flags[b]
Boilers (>250x10^6 Btu/hr)	1,040,900	2	
Nitric Acid (Air Oxidation)	8,100	17	7-2, 8-2

[a] Based on the promulgation of a revised NSPS.

[b] First number is the factor considered, second character is the flag. Definition of flags is given in Section 3.2.2.

Table 4-6b. Nitrogen Oxide Source Categories with No Major Constraints to Promulgation of NSPS (Group UN)

Category	Ts-Tn, 1985 (tons/year)	Ts-Tn Rank	Constraint and Priority Flags[a]
Stationary Gas Turbines[b]			
Electric Utility	1,060,000	1	
Gas Pipeline	158,000	6	
Boilers (10-250x10^6 Btu/hr)	553,884	4	
Explosives (High)	229,000	5	
Mixed Fuel Boilers[b]			
Coal and Refuse	156,000	7	5-LE, 6-FL/LO
Oil and Refuse	2,200	22	5-LE, 6-FL/LO
Cement Plants (Kilns and Clinker Coolers)	25,100	11	7-0, 9-0
Municipal Incinerators	14,700	15	6-LO
Adipic Acid	3,900	20	
DMT/TPA (Nitric Acid Oxidation)	2,790	21	5-LE, 6-FL
Fiberglass (Wool Processing)	880	25	

[a] Definition of flags is given in Section 3.2.2.

[b] These sources are treated together.

Table 4-6c. Nitrogen Oxide Source Categories for Which an Equipment Standard is Preferable (Group EQ)

Category	Ts-Tn, 1985 (tons/year)	Ts-Tn Rank	Constraint and Priority Flags[a]
Internal Combustion Engines (Spark Ignition)	882,000	3	3-HC, 5-LE
Internal Combustion Engines (Diesel and Dual Fuel)	140,000	8	3-HC, 5-LE
Boilers ($0.3\text{-}10\times10^6$ Btu/hr)	56,200	10	5-FS, 7-3

[a] Definition of flags is given in Section 3.2.2.

Table 4-6d. Nitrogen Oxide Source Categories with Moderate Constraint Rating Due to Increased Energy Consumption or Scarce Resource Utilization (Group MCR)

Category	Ts-Tn, 1985 (tons/year)	Ts-Tn Rank	Constraint and Priority Flags[a]
Industrial/Commercial Incinerators	16,850	13	7-2, 10-OC
Explosives (Low)	15,800	14	8-2
Auto Body Incinerators	30	31	7-2, 8-0

[a] Definition of flags is given in Section 3.2.2.

Table 4-6e. Nitrogen Oxide Source Categories Requiring Control Technology Research and Development Prior to NSPS Promulgation (Group RD)

Category	Ts-Tn, 1985 (tons/year)	Ts-Tn Rank	Constraint and Priority Flags[a]
Boilers (<0.3x10^6 Btu/hr)	80,000	9	5-EQ
Glass Manufacture (Soda-Lime)	17,100	12	
Petroleum Refinery (Process Gas Combustion)	9,100	16	6-FL
Fiberglass (Textile Processing)	6,300	18	9-0
Lime Processing	5,600	19	
Brick and Related Clay Products	2,000	23	
Ceramic Clay	1,000	24	
Nitrate Fertilizer	720	26	
Byproduct Coke Ovens	720	27	
Pathological Incinerators	380	28	5-EQ
Glass Manufacture (Opal)	230	29	
Mineral Wool	160	30	
Coffee Roasting	15	32	

[a] Definition of flags is given in Section 3.2.2.

Table 4-6f. Nitrogen Oxide Source Categories for Which There Is No Control Technology Available (Group NC)

Category	Ts-Tn, 1985 (tons/year)[a]	Ts-Tn Rank	Constraint and Priority Flags[b]
Open Burning	306,200	N/A	4-NF, 5-LE, 9-0
Sugar Cane (Field Burning)	11,200	N/A	4-NF, 5-LE, 9-0
Steel Foundries	2,700	N/A	
Secondary Lead (Reverberatory Furnace)	140	N/A	
Secondary Zinc (Distillation)	9	N/A	
Secondary Lead (Blast Furnace)	5	N/A	
Secondary Zinc (Sweating)	5	N/A	
Magnesium Smelting	1	N/A	

[a] Based on an assumed value of $E_n = 0$.

[b] Definition of flags is given in Section 3.2.2.

Unconstrained (UN)

The sources in this group on Table 4-6b have no major constraints to hinder the application of NSPS. The electric utility and pipeline gas turbines are treated together as are the mixed fuel (refuse/fossil fuel) boilers. The normalized standard development effort is as follows:

Category	Normalized Standard Development Effort
Stationary Gas Turbines	
Electric Utility	0.5
Gas Pipeline	0.5
Mixed Fuel Boilers	
Coal and Refuse	0.5
Oil and Refuse	0.5

The mixed fuel boilers and municipal incinerators are flagged as being location sensitive because of their siting in or near urban areas. Control of cement plant kilns and clinker coolers results from a process redesign that reduces fuel consumption; hence, the energy conservation and other pollutant control flags.

Some legal considerations arise for the mixed fuel boilers and DMT/TPA plants. For the boilers, there is some overlap in the NSPS for incinerators and boilers with this category. A precise definition of a mixed fuel boiler as compared to the other sources is necessary. For DMT/TPA plants, the TRC review indicated that the emission-producing processes may be phased out by all but one corporation. The standard would then result in the regulation of only one company.

Equipment Standard Preferrable (EQ)

Internal combustion engines, both spark ignition and diesel and dual fuel, are included in this group because of the large number of individual sources that would make compliance testing extremely difficult. An alternative to field tests would be production line tests, either selective sampling or 100% sampling, but this too would present enforceability complications. In addition, control of these sources through design modifications is expected to result in substantial cost penalties, estimated as high as 20-30% increase in capital expenditures.

The boilers in the 0.3-10 x 10^6 Btu/hr range are included in this group because fuel switching is the most cost-effective control method. The large number of sources may make a fuel standard more readily enforceable than an emission limit. At the same time, a fuel standard would have significant energy use implications as indicated by the rating of 3.

Moderate Constraint Rating (MCR)

Control of industrial/commercial incinerators is achieved with medium energy wet scrubbers, hence the rating of 2 on factor 7. Another consideration may come into play for these sources; the wide range in source size (50-4000 lb/hr charging rate) may make a subdivision of the category by unit size desirable.

For low explosives, control is achieved through catalytic decomposition, which requires the use of rare metals. For auto body incinerators, an afterburner is used for control of all pollutants; this is a high-energy-consuming device but the effect is minimized since the gas flow volumes are small.

From the above considerations it is evident that these constraints are not very restrictive and could be relaxed with minimum impacts.

Research and Development Required (RD)

The sources in this category have no control technology currently in widespread use although some system is either under development or is a carryover from similar industries. In most cases, the required research would have to be conducted in combustion and flame kinetics since the emissions result primarily from fuel combustion. Combustor design to minimize NO_x emissions would likely be the most readily adaptable control technique.

For the small boilers (<.3 x 10^6 Btu/hr) and the pathological incinerators, an equipment standard would be preferrable to an emission limit due to the large number of sources. For fiberglass textile processing the control technique is a switch to electric furnaces, which results in control of all pollutants. Research is needed to determine the applicability of the electric furnace to this process.

No Demonstrated Control Technology Available (NC)

For open burning and sugar cane field burning, the only control method is to prohibit the practice. The remaining source categories are metallurgical processes. With the exception of steel foundries, the combustion of fuel is carefully controlled as a part of process requirements. Modification of flame temperatures to achieve NO_x control would not be possible without substantially affecting the quality of the final product. In addition, the Ts-Tn values of these sources are too low to warrant extensive control program development.

Table 4-7 shows the effect of imposing the source constraints on the standard-setting priority. The first four strategies correspond to the curves of Fig. 4-3 with Strategy 3 serving as the baseline for the efficiency ratio calculation.

Strategy 5 sets the standards for the unconstrained group first in Ts-Tn order. The equipment standard group is considered to have a lesser constraint than the MCR group. This ordering is further reinforced by the fact that the EQ group has a very large emission reduction potential while the MCR group does not. The sources requiring research and development are considered last, while those with no control technology available are not regulated at all. At the rate of 4 NO_x standards per year, the RD group is reached in 1979. Revised standards for the large boilers and nitric acid plants are set in 1980. The imposition of these constraints results in 1990 emissions increasing by 52.9% over 1975 values, and the efficiency ratio dropping off to 86.4% as compared to 94.4% for the strict Ts-Tn order. Strategy 6 shows that the efficiency can be increased to 89.5% through an acceleration of the standard setting pace to 10 per year, but the RD group is now reached in 1977, which may be too soon for the necessary research to be completed.

Strategy 7 shows that, by relaxing the EQ constraint, a significant improvement in emission reduction can be realized. This is being primarily influenced by the setting of standards for the internal combustion engines, which have very high Ts-Tn potential. Strategy 8 shows that relaxing this constraint on these sources only, while maintaining it on the small boilers (0.3-10 x 10^6 Btu/hr), costs virtually nothing in emission reduction potential. The clear indication is that the control of the internal combustion engines should be made a matter of high priority for NO_x control.

Table 4-7. Nitrogen Oxide Priority Strategy Summary[a]

Priority Strategy[b,c]	Standard Setting Rate (no./yr)	1985		1990		
		Emissions (10^6 tpy)	% Change from 1975	Emissions (10^6 tpy)	% Change from 1975	Efficiency Ratio (%)[d]
1. State standards only		19.08	+71.3	24.10	+116.3	-10.7
2. Only existing NSPS and state standards		18.45	+65.6	23.04	+106.8	0
3. All NSPS set in 1975		13.99	+25.6	16.10	+ 44.4	100.0
4. NSPS set in Ts-Tn order	4	14.38	+29.1	16.49	+ 47.9	94.4
5. Postpone constraint groups (UN/EQ/MCR/RD)	4	14.94	+34.1	17.04	+ 52.9	86.4
6. Postpone constraint groups (UN/EQ/MCR/RD)	10	14.72	+32.1	16.83	+ 51.0	89.5
7. Relax EQ constraint (UN/MCR/RD)	4	14.77	+32.6	16.87	+ 51.4	88.8
8. Relax EQ constraint for internal combustion engines only (UN/EQ/MCR/RD)	4	14.78	+32.6	16.88	+ 51.5	88.7
9. Relax MCR constraint (UN/EQ/RD)	4	15.03	+34.9	17.14	+ 53.8	85.0
10. Postpone revised NSPS (UN/EQ/MCR/RD/ES (revised))	4	15.21	+36.5	17.31	+ 55.3	82.5

[a] Stationary sources only.

[b] All strategies exclude standards for group with no demonstrated control technology (NC). The unconstrained (UN) group includes all sources in Ts-Tn order unless a specific constraint is involved.

[c] Except for Strategy 1, all strategies assume existing NSPS to be in effect in 1975. Except for Strategies 1-4, all revised NSPS are subject to at least a 5-year delay in addition to other constraints that may be involved in the revision.

[d] Computed from the formula $[(E_2-E_{strategy})/(E_2-E_3)]_{1990} \times 100\%$; i.e., Eqn. 3-15 where E_2 (Strategy 2) is E_{max} and E_3 (Strategy 3) is E_{min}.

Strategy 9 shows the effect of relaxing the moderate constraint rating considerations while maintaining the other constraints. The 1990 efficiency ratio drops to 85.0% or 1.4% lower than for the full constraint approach of Strategy 5. This is a result of the delaying of standards for the large sources in the EQ group to control the smaller sources in the MCR group. Given the difficulties with controlling NO_x emissions, this is an unacceptable approach.

For all of the strategies thus far, the revised NSPS for the large boilers and nitric acid plants are set in 1980. Strategy 10 shows the impact of delaying the setting of a revised standard until all others have been set, including the RD group. The standards are set in 1982 at the 4 per year rate. It is evident that this results in the worst 1990 efficiency ratio and the largest emission increases except for Strategies 1 and 2. The implementation of such a strategy is clearly not advisable and the setting of a revised standard should not be delayed indefinitely.

From the above analysis, Strategy 8 appears to be the most effective in reducing emissions while considering the constraints affecting each source. Its impact on emissions is shown by Curve 5 on Figs. 4-3 and 4.4

4.5 POLLUTANT PRIORITY ANALYSIS - HYDROCARBONS

The control of hydrocarbon emissions is a multifaceted problem because of the combined influence of mobile and stationary sources. Figure 4-5 indicates the potential for controlling stationary sources via the NSPS mechanism. Curve 1 indicates the increase in stationary source hydrocarbon emissions without the application of any NSPS and with only SIP regulations. Emissions in 1990 are double the 1975 values. To date, the only hydrocarbon standards that have been promulgated are for petroleum storage vessels and Curve 2 indicates their impact on emissions. It is evident that there is a great deal of additional control potential since the storage vessel NSPS results in only a 6% decrease in 1990 emissions.

The maximum control potential achieved by the setting of standards for all industries immediately is shown by Curve 3. Excluded from the standard setting procedure are source categories for which there is no control technology available. The 1990 emissions are reduced to 17% less than 1975 emissions and to 58% less than the SIP-controlled case. The indication is that

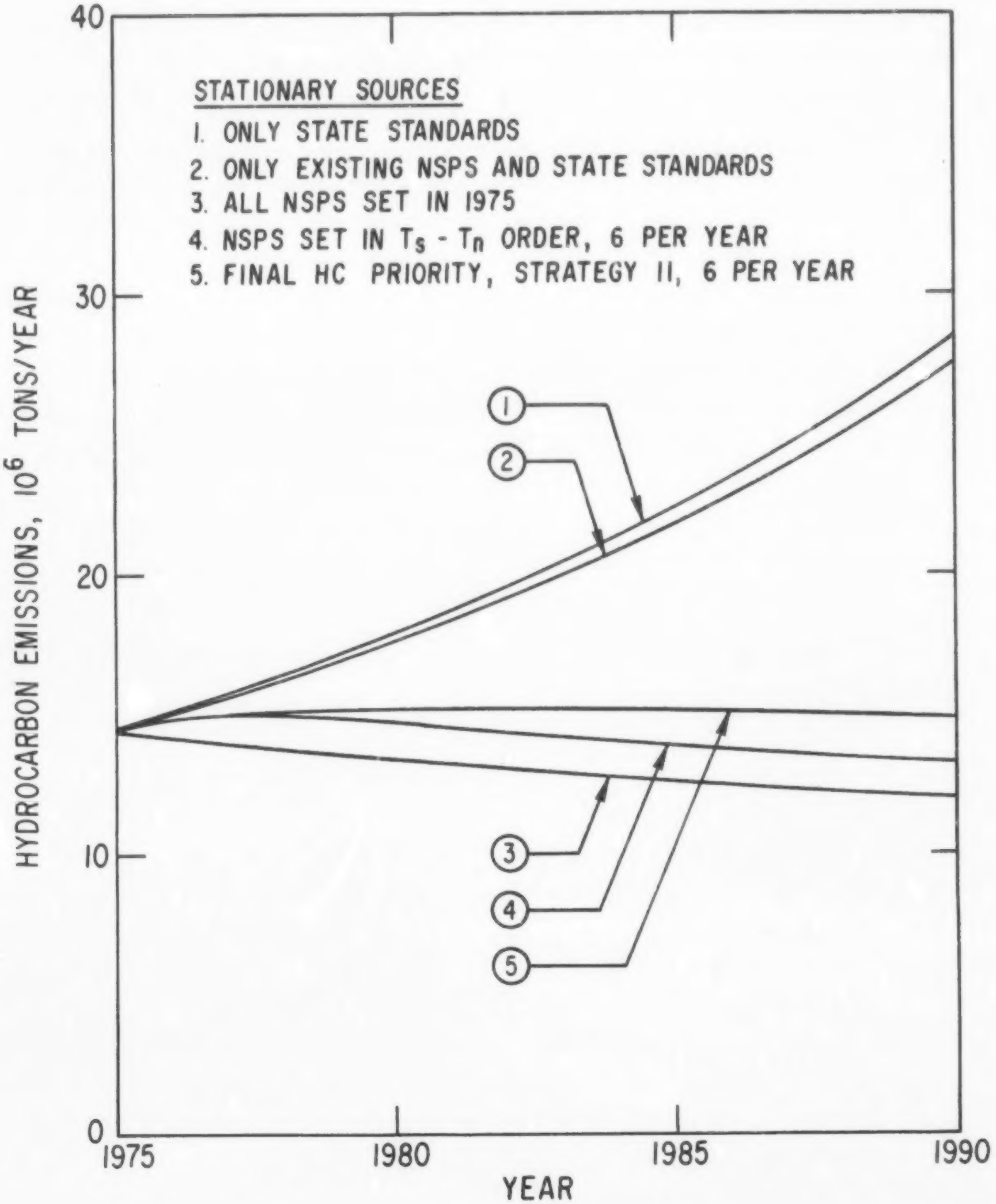

Fig. 4-5. Hydrocarbon Emission Projections for Stationary Sources

even the most drastic of stationary source controls will provide little more than a holding action on hydrocarbon emissions relative to their current levels but will provide substantial control over the unregulated case.

Curve 4 on the figure indicates the effect of a nominal standard-setting rate (6 hydrocarbon standards per year) on emissions. The priority is based strictly on the Ts-Tn rank and shows an 8% reduction in 1990 emissions over 1975 values, which is only slightly less than the maximum impact case. The relatively small difference between setting the standards at 6 per year versus setting them all at once is a result of the dominance of several large source categories at the top of the Ts-Tn list. The first six sources plus the petroleum storage vessels account for more than half of the Ts-Tn emission reductions based on the TRC calculations for 1985. Once the standards are set for these industries, the remaining will have only a small effect on emission rates. In terms of total emissions, the differences between setting all the standards at once and setting 6 standards per year is about 1.27 million tons/year in 1990.

Curve 5 of the figure represents the final priority strategy, which will be discussed later.

Figure 4-6 shows the effect of the control of stationary sources through NSPS and the control of motor vehicle emissions through the Mobile Source Pollution Control Program (MSPCP). The first four curves are for the same four standard-setting strategies as considered above for stationary sources alone. The details of the motor vehicle emission computations are given in Appendix A. Curve 1 shows that even without any controls on stationary sources, hydrocarbon emissions will decrease as a result of the MSPCP and reach a minimum in about 1980. Beyond that time, the growth in motor vehicle traffic volume plus the growth in stationary sources will overtake the gains made by the motor vehicle controls and will result in a net increase in emissions in 1990 of about 19%. As before, the existing NSPS for petroleum storage vessels (Curve 2) do not alter the trend very much.

The effect of promulgating additional NSPS are shown on Curves 3 and 4. The NSPS program is capable of counteracting the growth trends and bringing about an emission reduction in 1990 of 41% over 1975 levels (37% for the 6 standards per year pace). This is equivalent to preventing over 16 million tons/year in 1990 compared to the uncontrolled case. Even with this large

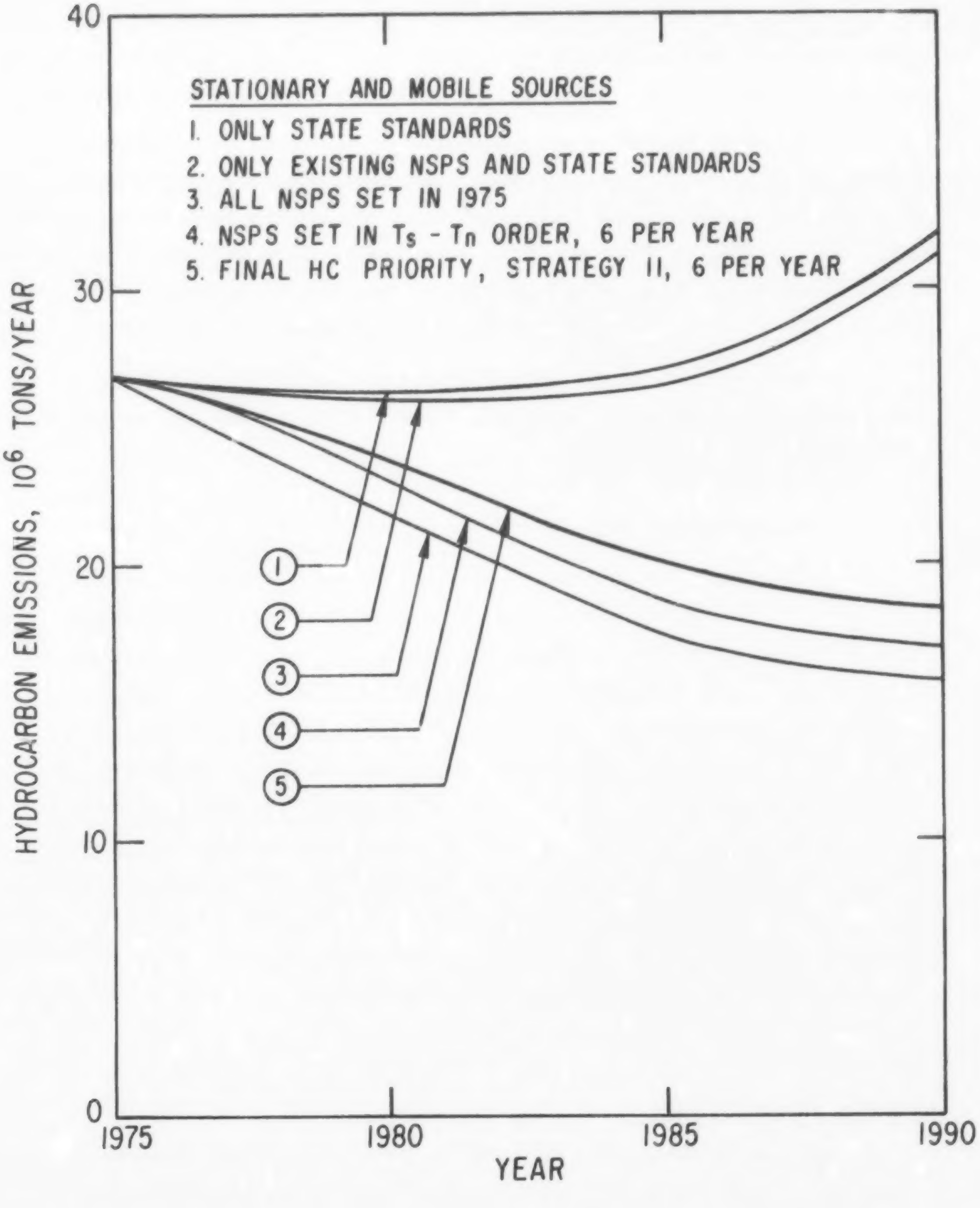

Fig. 4-6. Hydrocarbon Emission Projections for Stationary and Mobile Sources

impact, Curves 3 and 4 show a definite leveling off, indicating that, beyond 1990, emissions will again begin to increase if no further controls are placed on motor vehicles. Curve 5 is again the final priority strategy.

Prior to beginning the analysis of the impact of alternative standard-setting priorities based on individual source constraints, it can be noted that there is some potential for revising the prioritization and still maintaining at least no increase in hydrocarbon emissions in the time frame considered. This is only a limited capability, however, since the maximum impact case yields only a 17% decrease from 1975 emissions in 1990.

Based on the source screening methodology described in Sec. 3.0, the hydrocarbon sources were separated into seven groups. These are indicated on Table 4-8a to 4-8g.

Existing NSPS (ES)

This group on Table 4-8a consists of all source categories for which there is an existing standard. For hydrocarbons, this includes only petroleum storage vessels and is limited to the storage of liquids with a vapor pressure greater than 78 mm of Hg and less than 570 mm of Hg and to storage tanks of greater than 40,000 gallon capacity. For source categories included in the TRC data, it is assumed that the standard applies to the breathing and working losses associated with the storage of crude oil, gasoline, jet fuel, naptha, and aviation gas. It is not assumed to apply to kerosene and distillate oil because of their low vapor pressure. (Actually, jet fuel and naptha are only marginally included in the minimum requirement.) Emissions from petroleum transfer are not included in this category since these most frequently involve mobile tanks and stationary facilities that are smaller than the 40,000 gallon size cutoff. This source category is not considered for a revised standard since the existing NSPS already specifies best available control technology.

In addition to this category, regulation has been proposed for vehicle refueling. This regulation was not treated as an existing NSPS here.

Unconstrained (UN)

This group on Table 4-8b includes all source categories for which there are no constraints to the application of NSPS. In this group, the

Table 4-8a. Hydrocarbon Source Categories with Existing NSPS (Group ES)

Category	Ts-Tn, 1985 (tons/year)	Ts-Tn Rank	Constraint and Priority Flags
Petroleum Storage	N/A[a]	N/A[a]	
Aviation Gas-Breathing			
Aviation Gas-Working			
Crude Oil-Breathing			
Crude Oil-Working			
Gasoline-Breathing			
Gasoline-Working			
Jet Fuel-Breathing			
Jet Fuel-Working			
Special Naphtha-Breathing			
Special Naphtha-Working			

[a] Not applicable, since these sources are not candidates for revised NSPS; i.e., the present NSPS is felt to represent the best control technology.

Table 4-8b. Hydrocarbon Source Categories with No Major Constraints to Promulgation of NSPS (Group UN)

Category	Ts-Tn, 1985 (tons/year)	Ts-Tn Rank	Constraint and Priority Flags[a]
Ammonia (Methanator Plant)	750,000	2	7-0
Ammonia (Regenerator and CO Absorber)	750,000	3	7-0
Degreasing	527,000	4	
Carbon Black (Furnace Process)	318,000	9	7-0, 9-0
Charcoal	143,000	13	7-0
Graphic Arts (Gravure)	128,000	14	
Beer	43,000	27	7-0
Vegetable Oil	37,400	30	
Petroleum Storage[b]			
Distillate Oil-Breathing	31,700	35	5-EQ,[c] 7-0
Kerosene-Breathing	1,600	57	
Synthetic Resin (Acrylic)	31,000	36	
Synthetic Fibers (Nylon)	11,300	45	
Whiskey	1,540	58	
Synthetic Fibers (Acetate)	1,000	62	
Textile Processing (Heat Setting/Finishing)	850	64	
Textile Processing (Carpet Manufacture)	590	65	
Styrene-Butadene Rubber	240	67	
Lead Acid Battery Plant	210	69	
Synthetic Resin (Alkyd)	187	70	
Textile Processing (Texturizing)	170	73	

[a] First number is the factor considered; the second character is the flag. Definition of flags is given in Section 3.2.2.

[b] These sources are treated together.

[c] Despite the fact that these sources carry an EQ flag, they are included in the UN group, since an equipment NSPS already exists for storage of other liquids.

Table 4-8c. Hydrocarbon Source Categories for Which an Equipment Standard is Preferable (Group EQ)

Category	Ts-Tn, 1985 (tons/year)	Ts-Tn Rank	Constraint and Priority Flags[a]
Industrial Surface Coating	2,560,000	1	6-WS
Petroleum Refinery (Miscellaneous Point Sources)	505,000	5	4-NF, 6-FL, 7-0, 10-0
Petroleum Refueling[b]	384,000	8	4-NF, 5-LE, 6-WS, 7-0
Drycleaning	204,000	10	6-WS
Petroleum Service Stations	175,000	12	4-NF, 6-WS, 7-0
Petroleum Transfer[c]			4-NF, 6-WS, 7-0
Gasoline	32,400	34	
Crude Oil	11,300	46	
Jet Fuel	4,200	51	
Aviation Gas	990	63	
Special Naphtha	130	74	
Direct Firing of Meats	30,300	39	6-WS, 9-0
Internal Combustion Engines (Diesel and Dual Fuel)	2,500	52	5-LE, 6-WS
Pathological Incinerators	60	75	5-LE, 6-WS, 7-2[d]

[a] Definition of flags is given in Section 3.2.2.

[b] A regulation has been proposed for this source.

[c] These sources are treated together.

[d] Despite the fact that the afterburners require additional fuel consumption, the nature of the waste may bring public demand for control; therefore, these sources are included here instead of further down the priority list.

Table 4-8d. Hydrocarbon Source Categories with Uncertain Energy Impact due to Unknown Gas Flammability (Group UGF)

Category	Ts-Tn, 1985 (tons/year)	Ts-Tn Rank	Constraint and Priority Flags[a]
Graphic Arts (Flexography)	115,000	16	
Petroleum Refinery (Vacuum Distillation)	83,800	18	6-FL
Graphic Arts (Letter Press)	77,500	20	
Graphic Arts (Lithography)	73,900	21	
Graphic Arts (Metal Decorating)	69,100	22	
Cast Iron Foundry (Core Oven)	63,700	24	
Paint	60,000	26	
Polyethylene (Low Density)	30,900	37	
Maleic Anhydride (Benzene Oxidation)	30,700	38	
Polyethylene (High Density)	26,300	40	
Varnish	18,100	42	
Phthalic Anhydride (O-xylene)	17,900	43	6-FL
Polyvinyl Chloride	12,000	44	
Printing Ink	6,900	47	
Wood Processing (Plywood)	6,200	48	
Deep Fat Frying	5,300	49	9-0
Polystyrene	4,700	50	

Table 4-8d. (Contd.)

Category	Ts-Tn, 1985 (tons/year)	Ts-Tn Rank	Constraint and Priority Flags[a]
Synthetic Resins (Phenolic)	2,480	53	
Asphalt Roofing (Blowing)	2,400	54	6-WS
Mineral Wool	2,000	55	
Synthetic Resins (Urea-Melamine)	1,806	56	
Fiberglass (Wool Processing)	1,400	59	
Synthetic Resins (ABS-SAN)	1,127	60	
Polypropylene	1,100	61	6-FL
Coffee Roasting	290	66	
Auto Body Incinerators	230	68	
Secondary Zinc (Sweat Furnace)	180	71	
Meat Smokehouses	170	72	9-0
Secondary Magnesium Smelting	10	76	

[a] Definition of flags is given in Section 3.2.2.

Table 4-8e. Hydrocarbon Source Categories with Moderate Constraint Rating due to Increased Energy Consumption or Scarce Resource Utilization (Group MCR)

Category	Ts-Tn, 1985 (tons/year)	Ts-Tn Rank	Constraint and Priority Flags[a]
Ethylene Oxide	434,000	7	8-2
Acrylonitrile	65,400	23	7-2
Formaldehyde	63,300	25	7-2
Ethylene Dichloride	36,200	32	3-HC, 6-FL, 7-2, 8-2

[a] Definition of flags is given in Section 3.2.2.

Table 4-8f. Hydrocarbon Source Categories Requiring Control Technology Research and Development Prior to NSPS Promulgation (Group RD)

Category	Ts-Tn, 1985 (tons/year)	Ts-Tn Rank	Constraint and Priority Flags[a]
Internal Combustion Engines (Spark Ignition)	499,000	6	5-LE/EQ, 6-WS
Boilers ($>250\times10^6$ Btu/hr)	186,000	11	9-2
Boilers ($0.3-10\times10^6$ Btu/hr)	124,000	15	5-EQ, 6-WS, 9-2
Boilers ($10-250\times10^6$ Btu/hr)	91,300	17	9-2
By-product Coke Ovens	77,900	19	
Auto Assembly Plants	42,900	28	
Industrial/Commercial Incinerators	39,800	29	10-OC
Boilers ($<0.3\times10^6$ Btu/hr)	37,200	31	5-EQ, 6-WS, 9-2
Asphalt Batching	33,700	33	6-WS
Municipal Incinerators	20,900	41	6-LO, 9-2

[a] Definition of flags is given in Section 3.2.2.

Table 4-8g. Hydrocarbon Source Categories for Which There Is No Control Technology Available (Group NC)

Category	Ts-Tn, 1985 (tons/year)[a]	Ts-Tn Rank	Constraint and Priority Flags[b]
Open Burning	3,062,500	N/A	4-NF, 5-LE, 9-O
Orchard Heaters	168,000	N/A	5-LE/EQ
Sugar Cane (Field Burning)	112,000	N/A	4-NF, 5-LE, 9-O
Wood Pulping (Kraft Process)	3,300	N/A	
Petroleum Refinery (Process Gas Combustion)	2,600	N/A	
Brick and Related Clay Products	620	N/A	6-WS

[a] Based on an assumed value of $E_n = 0$.

[b] Definition of flags is given in Section 3.2.2.

petroleum storage for categories for distillate oil and kerosene are grouped together since a standard could be set for both of them in much the same way as for the storage of other liquids. The normalized standard development effort is:

Category	Normalized Standard Development Effort
Petroleum Storage	
Distillate Oil-Breathing	0.5
Kerosene-Breathing	0.5

Six of the source categories are rated as having an energy conservation effect (factor 7 related as 0) as a result of NSPS control. For ammonia manufacture (both methanator and regenerator and CO absorber), carbon black (furnace process), charcoal, and beer processing, the hydrocarbons are controlled with an afterburner. The exhaust gases are combustable and require no additional fuel input; thus, heat recovery is possible for use in other portions of the manufacturing process. For petroleum storage, the energy conservation results from minimizing the loss of material. Although the petroleum storage category is flagged as having a need for an equipment standard, it is included here since a similar standard exists for the storage of other liquids; that is, no enforceability problems can be expected.

The carbon black (furnace process) category is also rated as having additional pollutant control potential as a result of hydrocarbon control (factor 9 rated as 0) since the afterburner is used for sulfide control.

Equipment Standard Preferable (EQ)

Sources in this group on Table 4-8c have one or more special problems that would make the enforcement of a NSPS difficult. With the exception of petroleum refineries, all of the categories have an exceptionally large number of individual sources that would make compliance testing for each source an impractical task. For the miscellaneous point sources at refineries (as well as for petroleum refueling, petroleum service stations, and petroleum transfer) it is not feasible to measure emissions since they are not released through a single point such as a stack. These considerations tend to support the use of an equipment standard, rather than an emission standard, as the preferred NSPS control option. The legal problems associated with the use of this type of standard have already been discussed.

Some legal problems are associated with the control of the petroleum refueling category. Coordination with the Mobile Source Pollution Control Program would be necessary to define the method of control and the administering EPA division. (The recently proposed regulation was not considered here.) For the diesel and dual fuel internal combustion engines, the equipment standard might take the form of production line testing similar to the motor vehicle program rather than field testing. This presents compliance problems in that not all sources would be tested. A resolution of this situation relative to the requirements of Section 111 would be necessary.

Control of petroleum refineries, petroleum refueling, petroleum transfer, and petroleum service stations would result in fuel conservation (factor 7 rated as 0). Control of the direct firing of meats would control odors as well (factor 9 rated as 0). Pathological incinerators require an afterburner (factor 7 rated as 2) but the units are generally small and the nature of the waste may bring public demand for control. Hence, this category is included here rather than in one of the later groups.

The petroleum transfer sources are treated together with the following effort:

Category	Normalized Standard Development Effort
Petroleum Transfer	
Gasoline	0.2
Crude Oil	0.2
Jet Fuel	0.2
Aviation Gas	0.2
Special Naphtha	0.2

Uncertain Energy Impact Due to Unknown Gas Flammability (Factor 7 rated as 2) (UGF)

Sources in this group on Table 4-8d are rated as having a moderate energy impact as a result of NSPS since the control system requires the use of an afterburner. Insufficient information was available to determine if the waste gas was flammable and hence would not require additional fuel input or whether there was need for fuel to be added. It should be noted that for several source categories there was adequate information on the waste gas flammability. If the gas could be incinerated without additional fuel input, the source was included in the unconstrained (UN) group. If the information showed that fuel was required, the source was included in the moderate energy impact group discussed next.

Although there are a large number of source categories in this group, the emission impact is small. No single source contributes more than 1% of the total 1985 Ts-Tn reductions based on the TRC calculations and 2/3 of the sources each contribute less than 0.1%.

Moderate Constraint Rating (MCR)

Only four categories are included in this group on Table 4-8e. For the ethylene oxide industry, the control system for hydrocarbons is a catalytic converter. Since this requires the use of rare metals (usually platinum) it is given a moderate constraint rating for scarce resource utilization (factor 8 rated as 2). The acrylonitrile, formaldehyde, and ethylene dichloride categories require auxillary fuel in the afterburner and heat recovery is not attractive; hence, they are rated as having a moderate energy constraint (factor 7 rated as 2). The ethylene dichloride category has additional problems in that the corrosiveness of the waste requires special alloys and substantially increases the cost of control.

Research and Development Required (RD)

Sources in this group on Table 4-8f require additional research and development into control systems technology prior to the promulgation of NSPS. In some cases, such as the boilers, the research is needed on the process itself. In others, control systems are under development or are available but have not been applied to the industry. The other flags associated with each category are secondary to the RD consideration. The 10-OC flag for industrial/commercial incinerators indicates that other considerations may play a role in the standard-setting for this category. In this case, the wide range of incinerator size and design may require a subdivision of the category prior to NSPS development.

No Demonstrated Control Technology Available (NC)

There is no hydrocarbon control technology available for sources in this category on Table 4-8g apart from the cessation of operation. In the case of brick and related clay products, the only control is combustor maintenance, but this is done for other than air pollution control and no other system is available.

An evaluation of the effect of imposing the source constraints on the priority ranking is given on Table 4-9. The first four strategies are the same as the four considered on Fig. 4-5. Strategy 3 represents the maximum NSPS impact case and is the baseline against which the 1990 efficiency ratios are computed.

Strategy 5 sets priorities for the source categories at the rate of 6 per year based on the six constraint groups previously discussed. (The NC group is eliminated from the standard setting procedure.) Existing standards are assumed to be in effect in 1975 and the unconstrained group (UN) is considered in Ts-Tn order. The equipment standard (EQ) is assumed to be a less stringent constraint than the energy impacts indicated by the unknown gas flammability (UGF) and moderate constraint rating (MCR). Sources in the UFG group may or may not have an energy impact and so are considered before those with definite energy impacts in the MCR group. The research and development group (RD) is postponed to the end to allow time for the necessary research to be completed. (At the rate of 6 standards per year, NSPS for the RD group are set starting in 1985.) The use of this priority scheme results in a 1990 emission rate that is slightly higher (8.6%) than the 1975 rate, with peak emissions occurring in 1985. The implication of this procedure is that total hydrocarbon emissions will be allowed to increase through 1985 due to the various source constraints after which the promulgated standards will arrest the growth and, by 1990, bring the emission level almost back to the 1975 level. As measured by the 1990 efficiency ratio, this strategy yields about 76.6% of the maximum possible control.

If the standard-setting rate could be accelerated to 10 per year as shown in Strategy 6, then the peak emissions would be reached in 1978, the magnitude of the peak would be reduced by 0.81 million tons/year and the 1990 efficiency ratio would be increased to 86.2%, which is a 1.6% reduction

Table 4-9. Hydrocarbon Priority Strategy Summary[a]

Priority Strategy[b,c]	Standard Setting Rate (no./yr)	Maximum Emission Rate		1985		1990		
		(10^6 tpy)	(yr)	Emissions (10^6 tpy)	% Change from 1975	Emissions (10^6 tpy)	% Change from 1975	Efficiency Ratio (%)[d]
1. State standards only		28.44	1990	22.34	+55.0	28.44	+97.3	5.9
2. Only existing NSPS and state standards		27.53	1990	21.79	+51.2	27.53	+91.1	0.
3. All NSPS set in 1975		14.41	1975	12.62	-12.4	12.03	-16.5	100.
4. NSPS set in Ts-Tn order	6	14.89	1977	13.89	- 3.6	13.30	- 7.7	91.8
5. Postpone constraint groups (UN/EQ/UGF/MCR/RD)	6	16.15	1985	16.15	+12.0	15.66	+ 8.6	76.6
6. Postpone constraint groups (UN/EQ/UGF/MCR/RD)	10	15.34	1978	14.77	+ 2.5	14.17	- 1.6	86.2
7. Relax EQ constraint (UN/UGF/MCR/RD)	6	15.24	1985	15.24	+ 5.7	14.75	+ 2.4	82.5
8. Relax EQ constraint for industrial surface coating category only (UN/EQ/UGF/MCR/RD)	6	15.53	1985	15.53	+ 7.8	15.04	+ 4.4	80.6
9. Relax UGF and MCR constraints (UN/EQ/RD)	6	17.70	1984	17.69	+22.8	17.20	+19.4	66.7
10. Relax MCR constraint for ethylene oxide category only (UN/EQ/UGF/MCR/RD)	6	15.86	1980	15.80	+ 9.6	15.31	+ 6.2	78.9
11. Relax EQ constraint for industrial surface coating only and MCR constraint for ethylene oxide only (UN/EQ/UGF/MCR/RD)	6	15.25	1980	15.19	+ 5.4	14.70	+ 2.0	82.8
12. Relax all constraints except RD (UN/RD)	6	14.92	1977	14.64	+ 1.6	14.15	- 1.9	86.4
13. Relax RD constraint for internal combustion engines (spark ignition) (UN/EQ/UGF/MCR/RD)	6	15.81	1980	15.75	+ 9.3	15.24	+ 5.7	79.3

[a] Stationary sources only.

[b] All strategies exclude standards for group with no demonstrated control technology (NC). The unconstrained (UN) group includes all sources in Ts-Tn order unless a specific constraint is involved.

[c] Except for Strategy 1, all strategies assume existing NSPS to be in effect in 1975. Except for Strategies 1-4, all revised NSPS are subject to at least a 5-year delay in addition to other constraints that may be involved in the revision.

[d] Computed from the formula: $[(E_2 - E_{strategy}) / (E_2 - E_3)]_{1990} \times 100\%$; i.e., Eqn 3-15 where E_2 (Strategy 2) is E_{max} and E_3 (Strategy 3) is E_{min}.

in emissions from the 1975 levels. Acceleration of the rate would, of necessity, have to be accompanied by an earlier relaxation of the various constraints.

Strategies 7-13 reflect the result of selectively relaxing each of the constraints to determine emission impact. If the EQ constraint could be relaxed through a resolution of the enforceability problems and the sources could be included in the unconstrained group in Ts-Tn order as in Strategy 7, then the efficiency ratio could be improved to 82.5% in 1990. Emissions would still increase through 1985 but the magnitude of the peak would be reduced to 15.24 million tons/year as compared to 16.15 million tons/year for Strategy 5.

Review of the EQ group on Table 4-8c shows that the industrial surface coating category dominates the picture with more than 65% of the Ts-Tn potential in 1985. In Strategy 8, the EQ constraint is relaxed for this category only. The calculations show that the emission peak still occurs in 1985 and that the peak is 15.53 million tons/year or about 0.3 million tons higher than the peak resulting from the relaxation of all the EQ constraints. The 1990 efficiency ratio is 80.6% of maximum control potential and the emission rate is virtually unchanged compared to 1975 levels. This is a clear indication that if the enforceability problems of this source category could be resolved quickly, it would result in significant emission control improvement. The control potential of the other source categories in the EQ group is smaller in magnitude and the constraint need not be lifted prematurely for them.

In Strategy 9, the moderate constraints resulting from energy consumption and scarce resource utilization (groups UGF and MCR, factors 7 and/or 8 rated as 2) are relaxed. The result is a worsened emission picture with the peak being pushed back to 1984 and the 1990 efficiency ratio dropping to 66.7% of maximum control potential. The primary reason for this behavior is the generally small size and large number of sources in these categories. By relaxing these constraints while maintaining the EQ constraint, standards for the large sources in the EQ group are delayed until 1984. In comparison to the emission reductions achievable through the other strategies, this appears to be an unacceptable alternative. The fact that the setting of NSPS for these categories could increase national energy consumption further argues against premature relaxation of this constraint.

Review of the source categories in the UGF and MCR groups (on Tables 4-8d and 4-8e) shows the ethylene oxide industry to play the major role. Its inclusion in the MCR group is predicated on the need for scarce metals in the catalytic converter used for control. Strategy 10 shows the result of relaxing this constraint. On the basis of the industry's Ts-Tn rank, the standard is set in 1976. Peak emissions occur in 1980 and the 1990 efficiency ratio is increased to 78.9% as compared to 76.6% for Strategy 5.

Strategy 11 is a combination of Strategies 8 and 10. The constraints on the industrial surface coating and ethylene oxide industries are relaxed while all others are maintained. The result is an efficiency ratio of 82.8% of maximum control, which is higher than all others considered thus far except for the strict Ts-Tn order (Strategy 4) or the 10 standards per year rate (Strategy 6).

Strategy 12, shows the effect of relaxing all the constraints except RD. It represents the maximum control achievable with state-of-the-art technology. The 1990 efficiency ratio is 86.4% of maximum control and the emission peak occurs in 1977.

It is evident that the difference between Strategies 11 and 12 could be reduced by relaxing the EQ, UGF, and MCR constraints of an increasing number of sources until the desired level is attained. The question of what is the desirable level is a highly speculative issue. As an alternative to determining a numerical value of efficiency ratio, which is desired, it is possible to consider the implications of relaxing constraints on other sources in the groups. For the EQ group on Table 4-8c, it is clear that the industrial surface coating category has such a large Ts-Tn value that it must be considered a prime candidate for constraint relaxation. The only source category that has a larger Ts-Tn is open burning, which is in the NC group. The next source in the EQ group, miscellaneous point sources at petroleum refineries, presents numerous difficulties in identifying the actual source of emissions and determining the best control alternative. It seems intuitively apparent that control of these emissions has economic incentives as a result of the increasing price of crude oil and it is not clear that the effort required for the promulgation of a NSPS will be justified in the light of other incentives for control.

The third source on the list, petroleum refueling of cars, has complications resulting from the interface with the Mobile Source Pollution Control Program and would probably require extra time to develop a standard. The next two sources, drycleaning and petroleum service stations, have extremely large numbers of small sources. An EPA policy decision is needed to resolve the enforcement difficulties. The remaining sources have small Ts-Tn potential and hence do not have a critical requirement for constraint relaxation.

For the UGF and MCR groups, ethylene oxide is the only large source. Relaxation of constraints on other sources is of minimal effectiveness.

The conclusion to be drawn from this subjective and qualitative analysis is that relaxation of the constraints for industrial surface coating and ethylene oxide appear to be the only necessary ones at this time. Therefore, Strategy 11 is the most practical choice for hydrocarbon standard setting. Curve 5 on Figs. 4-5 and 4-6 shows the impact on emissions.

One last possibility needs to be considered. Strategy 13 is designed to investigate the impact of a research program to resolve the control problems for internal combustion (spark ignition) engines, which have a large Ts-Tn potential as shown on Table 4-8f. It is evident that this source category is approximately equivalent to the ethylene oxide category in terms of its emission impact. The 1990 efficiency ratio is improved to 79.3% (as compared to 76.6% for Strategy 5) if the control constraints for this source alone can be remedied. There is, therefore, a strong indication that a research effort designed to eliminate these problems would make a significant impact on hydrocarbon emissions.

4.6 POLLUTANT PRIORITY ANALYSIS - CARBON MONOXIDE

As with the control of nitrogen oxides and hydrocarbons, the control of carbon monoxide (CO) emissions is influenced by the interaction of mobile and stationary source categories. The set of stationary source emission curves is given on Fig. 4-7.

Only one CO NSPS has been set (the catalytic cracker units at petroleum refineries); one more has recently been promulgated (ferroalloy production) but, as discussed previously, is not included in this study. A significant amount of emission control has been achieved by the refinery standard as evidenced by the differences between Curves 1 and 2. The uncontrolled case

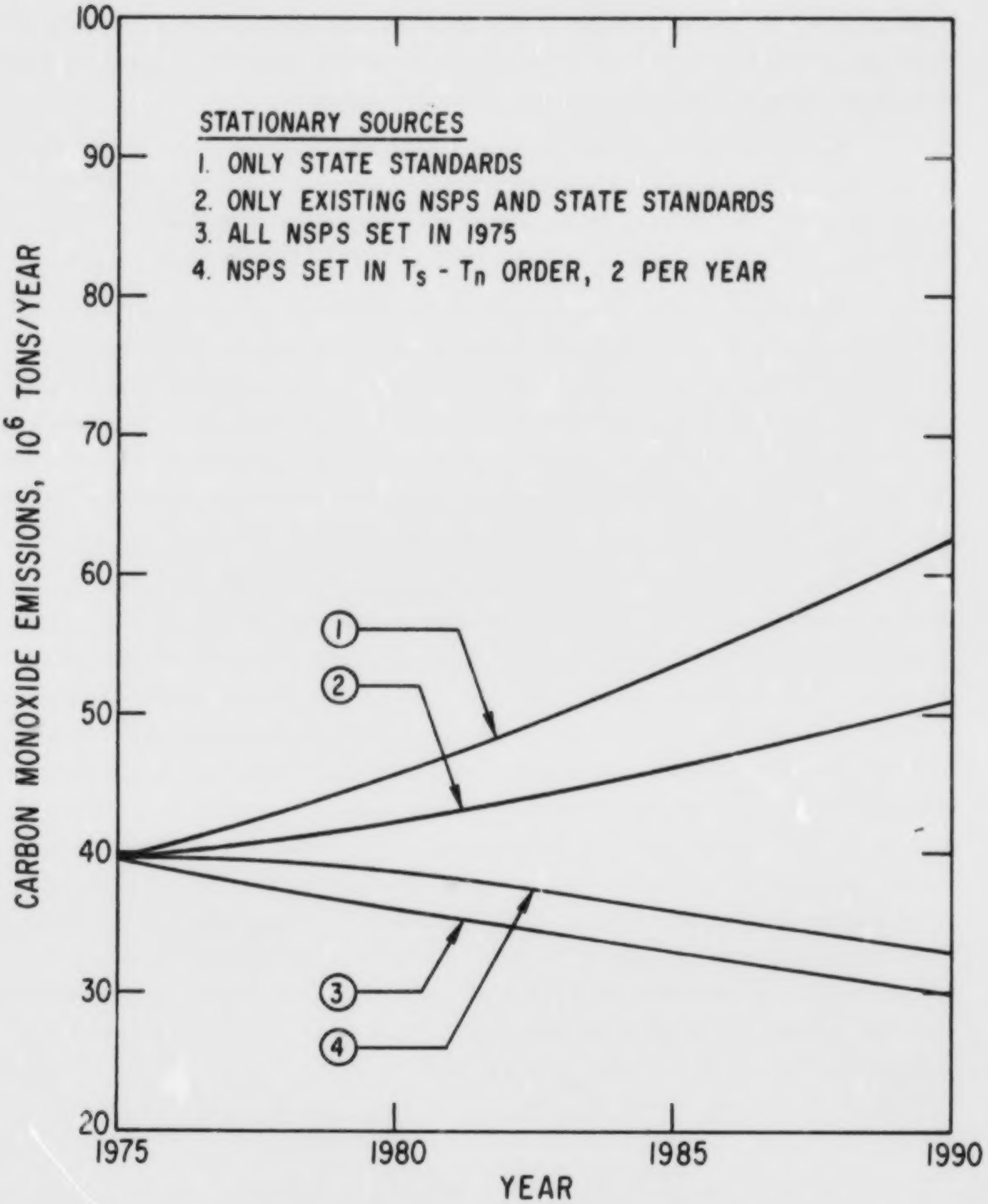

Fig. 4-7. Carbon Monoxide Emission Projections for Stationary Sources

results in a 1990 emission rate from stationary sources of over 62 million tons/year. The refinery NSPS reduces this to about 51 million tons, although this level is still amost 30% higher than 1975 rates.

Curve 3 shows that the maximum impact that can be expected through the setting of all standards immediately is a reduction of 24% over 1975 levels in 1990. By setting CO standards at the rate of 2 per year in strict Ts-Tn order, a 16.4% reduction is possible in 1990 as shown from Curve 4.

Figure 4-8 shows the behavior of CO emissions from both mobile and stationary sources. Motor vehicle emission controls result in a significant decrease in CO emissions through 1985 independent of stationary source controls. Beyond that time, the growth in vehicle miles traveled causes emissions to increase if no further stationary source controls are imposed (Curves 1 and 2). By promulgating additional NSPS, it is possible to counteract this growth and effect continuing emission reductions through 1990 (Curves 3 and 4).

The prioritization of CO sources was handled differently than for other pollutant sources. First, CO emissions from stationary sources do not, in most cases, represent a majority of the pollutant load in a region; nationally, stationary point sources account for 19% of the total CO emissions.[12] Second, control of CO is closely related to the control of hydrocarbons and nitrogen oxides. For fuel combustion sources, the steps used to reduce hydrocarbon emissions, such as design and firing modifications, will also control CO. Nitrogen oxide control also has impacts on CO emissions since flame temperatures, gas recirculation, and other methods must be carefully controlled to avoid increasing CO concentrations. For process sources where the hydrocarbon control technique is the use of an afterburner or incinerator, CO emissions are controlled at the same time. For these reasons, it was decided to prioritize the CO sources by linking them to the priorities that result from HC and NO_x control. For the source categories where there is no strong correlation between CO and HC or CO and NO_x, the normal priority screening routine was used.

Tables 4-10a to 4-10g give the constraint evaluations for all CO sources. Those categories where the priority is determined by hydrocarbon or nitrogen oxide considerations are appropriately noted.

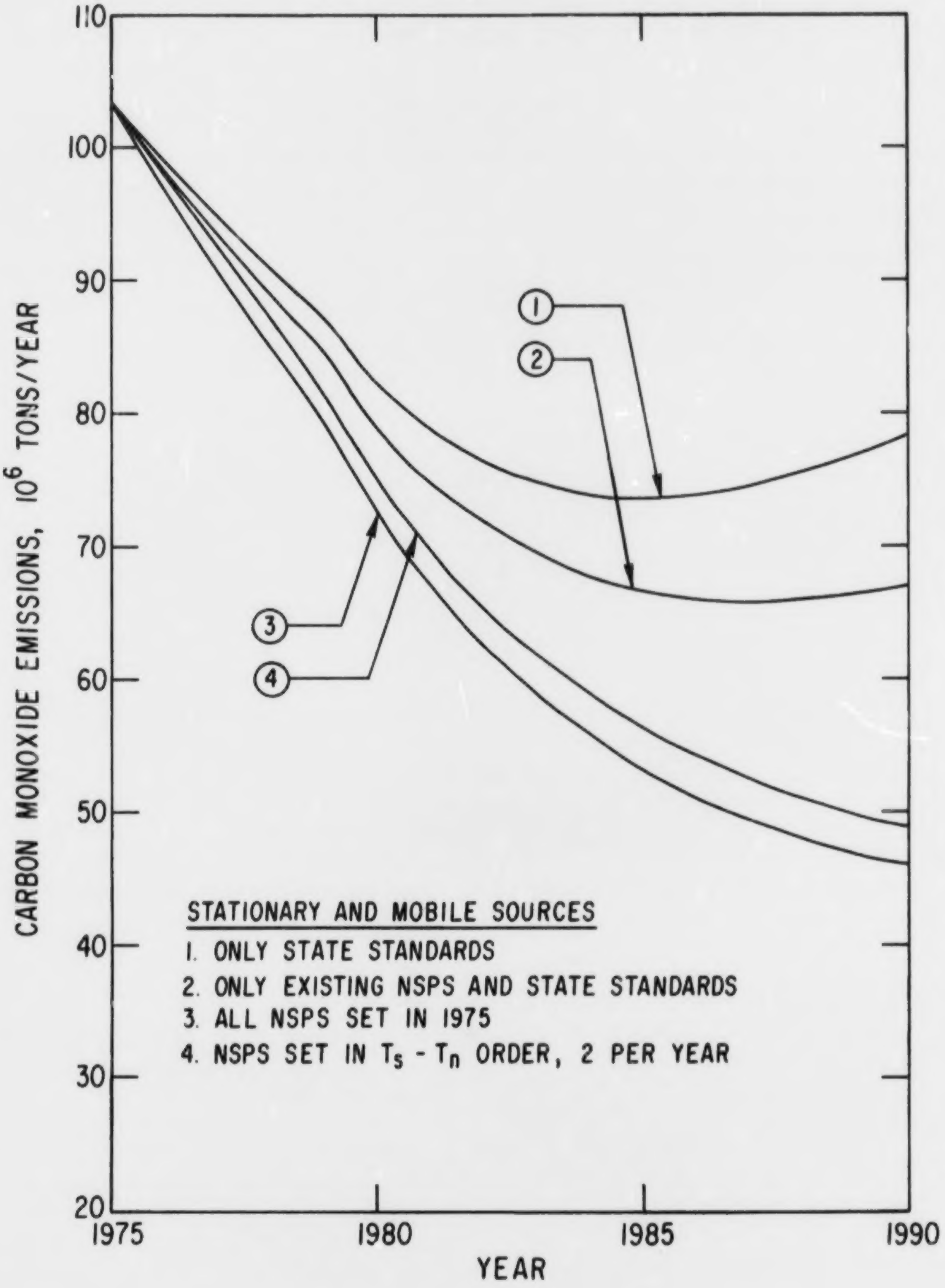

Fig. 4-8. Carbon Monoxide Emission Projections for Stationary and Mobile Sources

Table 4-10a. Carbon Monoxide Source Categories with Existing NSPS (Group ES)

Category	Ts-Tn, 1985 (tons/year)	Ts-Tn Rank	Constraint and Priority Flags[a]
Petroleum Refinery (FCCU)	N/A[a]	N/A[a]	

[a] Not applicable since this source is not a candidate for a revised NSPS; i.e., the present NSPS is felt to represent the best control technology.

Table 4-10b. Carbon Monoxide Source Categories with No Major Constraints to Promulgation of NSPS (Group UN)

Category	Ts-Tn, 1985 (tons/year)	Ts-Tn Rank	Constraint and Priority Flags[a]
Iron and Steel Plants (BOF)	4,130,000	1	7-0
Carbon Black (Furnace Process)	2,510,000	2	7-0, 9-0, with hydrocarbons
Ammonia (Regenerator and CO Absorber)	1,670,000	3	with hydrocarbons
Wood Pulping (Kraft Process)	471,000	5	with hydrocarbons
Stationary Gas Turbines			with nitrogen oxides
Electric Utility	446,000	6	
Gas Pipeline	60,600	21	
Iron and Steel Plants (Electric Arc)	225,000	13	
Charcoal	104,000	19	7-0, with hydrocarbons
Iron and Steel Plants (Blast Furnace)	53,280	22	7-0
Ferroalloy[b]	41,600	24	

[a] First number is the factor considered, second character is the flag. Definition of flags is given in Section 3.2.2.

[b] A NSPS has recently been promulgated for this source.

Table 4-10c. Carbon Monoxide Source Categories for Which An Equipment Standard is Preferable (Group EQ)

Category	Ts-Tn, 1985 (tons/year)	Ts-Tn Rank	Constraint and Priority Flags[a]
Internal Combustion Engines (Diesel and Dual Fuel)	137,000	17	5-LE, 6-WS, with hydrocarbons
Pathological Incinerators	60	32	5-LE, with hydrocarbons

[a] Definition of flags is given in Section 3.2.2.

Table 4-10d. Carbon Monoxide Source Categories with Uncertain Energy Impact Due to Unknown Gas Flammability (Group UGF)

Category	Ts-Tn, 1985 (Tons/year)	Ts-Tn Rank	Constraint and Priority Flags[a]
Maleic Anhydride (Benzene Oxidation)	279,800	9	with hydrocarbons
Mineral Wool	161,000	15	with hydrocarbons
Phthalic Anhydride (O-xylene Process)	61,200	20	6-FL, with hydrocarbons
Secondary Lead Smelter (Blast Furnace)	6,000	27	with hydrocarbons
Asphalt Roofing (Blowing)	1,400	28	with hydrocarbons
Auto Body Incinerators	1,100	29	with hydrocarbons
Meat Smokehouses	500	31	9-0, with hydrocarbons
Fiberglass (Wool Processing)	60	33	with hydrocarbons
Secondary Zinc (Sweat Furnace)	1	34	with hydrocarbons
Magnesium Smelting (Secondary)	0.5	35	with hydrocarbons

[a] Definition of flags is given in Sec. 3.2.2.

Table 4-10e. Carbon Monoxide Source Categories with Moderate Constraint Rating Due to Increased Energy Consumption or Scarce Resource Utilization (Group MCR)

Category	Ts-Tn, 1985 (tons/year)	Ts-Tn Rank	Constraint and Priority Flags[a]
Formaldehyde	386,000	7	7-2, with hydrocarbons
Acrylonitrile	259,000	11	7-2, with hydrocarbons
Ethylene Dichloride	29,700	25	3-HC, 6-FL, 7-2 8-2, with hydrocarbons

[a] Definition of flags is given in Section 3.2.2.

Table 4-10f. Carbon Monoxide Source Categories Requiring Control Technology Research and Development Prior to NSPS Promulgation (Group RD)

Category	Ts-Tn, 1985 (tons/year)	Ts-Tn Rank	Constraint and Priority Flags[a]
Iron and Steel Plants (Sintering)	786,000	4	
Internal Combustion Engines (Spark Ignition)	381,000	8	5-LE/EQ, 6-WS, with hydrocarbons
Municipal Incinerators	269,000	10	6-LO, 9-2 with hydrocarbons
Boilers ($>250\times10^6$ Btu/hr)	236,000	12	9-2, with hydrocarbons
Boilers ($10-250\times10^6$ Btu/hr)	223,000	14	9-2, with hydrocarbons
Boilers ($0.3-10\times10^6$ Btu/hr)	151,000	16	5-EQ, 6-WS, 9-2 with hydrocarbons
Industrial/Commercial Incinerators	123,900	18	10-OC, with hydrocarbons
Boilers ($<0.3\times10^6$ Btu/hr)	50,900	23	5-EQ, 6-WS, 9-2 with hydrocarbons
By Product Coke Ovens	22,700	26	with hydrocarbons
Fiberglass (Textile processing)	990	30	9-0, with nitrogen oxides

[a] Definition of flags is given in Section 3.2.2.

Table 4-10g. Carbon Monoxide Source Categories for Which There is No Control Technology Available (Group NC)

Category	Ts-Tn, 1984[a] (tons/year)	Ts-Tn Rank	Constraint and Priority Flags[b]
Open Burning	15,312,300	N/A	4-NF, 5-LE, 9-0
Sugar Cane (Field Burning)	561,000	N/A	4-NF, 5-LE, 9-0
Brick and Related Clay Products	1,300	N/A	
Chlor-Alkali (Diaphragm)	970	N/A	
Chlor-Alkali (Mercury Cell)	370	N/A	
Orchard Heaters	70	N/A	5-LE, EQ

[a] Based on an assumed value of $E_n = 0$.

[b] Definition of flags is given in Section 3.2.2.

Existing NSPS (ES)

For the catalytic cracking unit at refineries, the control technique is incineration that represents best available control, hence there is no revised standard proposal. A CO NSPS has been proposed for the ferroalloy industry but this has been ignored in this analysis as have the other pollutants.

Unconstrained (UN)

On this group shown on Table 4-10b, only the iron and steel sources (basic oxygen furnace, electric arc furnace, and blast furnace) and ferroalloy require a CO NSPS independent of hydrocarbon or nitrogen oxide controls. The Ts-Tn value determined by TRC for the ferroalloy industry is based on best available control, which is more stringent than the proposed standard.

The stationary gas turbine engines are treated together with the following effort:

Category	Normalized Standard Development Effort
Stationary Gas Turbines	
Electric Utility	0.5
Gas Pipeline	0.5

Equipment Standard Preferrable (EQ)

Both sources on Table 4-10c involve combustion processes and hence CO control can be linked to HC control.

Unknown Gas Flammability (UGF)

All sources in this group on Table 4-10d are controlled for hydrocarbons by an afterburner and CO control follows.

Moderate Constraint Rating (MCR)

All sources in this group on Table 4-10e use afterburners for control of hydrocarbons and CO control follows.

Research and Development Required (RD)

Only the iron and steel sintering operation of the sources on Table 4-10f requires separate CO control. All others are linked to HC or NO_x. The 10-OC flag for industrial/commercial incinerators indicates that source category subdivision (based on incinerator size or design) may be desirable prior to NSPS development.

No Demonstrated Control Technology Available (NC)

There is no control available for sources in this group (Table 4-10g).

Table 4-11 shows the effect of the standard-setting strategies for CO. The first four are the same as the four curves of Fig. 4-7. Strategy 5 considers the imposition of the various constraints on the setting of CO standards only. It does not include the effect of the linkage between CO and HC or CO and NO_x, which will be discussed in the next section on multipollutant analyses. The table shows that the constraints reduce the 1990 efficiency ratio to 75.0%, but the emission rates are still 10.6% below 1975 levels. Strategy 6 shows the effect of accelerating the pace to ten CO standards per year. This brings the efficiency ratio up to better than that of the strict Ts-Tn order of Strategy 4.

4.7 COMBINED POLLUTANT PRIORITY RANKING

The previous Sections 4.2-4.6 have evaluated alternate priority strategies separately for each criteria pollutant within the constraints of specified standard-setting rates using nominal values of 6 per year for TSP, 4 for SO_2, 4 for NO_x, 6 for HC, and 2 for CO, or a total of 22 per year. For a combined pollutant priority ranking, time variations in the standard-setting rate can be allowed for each pollutant to give a higher rate initially to priority pollutants, and vice versa, while still maintaining a constant total standard-setting rate over the period considered. This section discusses the results of such a combined pollutant analysis using as the tool a computerized version of the evaluation procedure described in Section 3.2.3.

A critical feature of the multipollutant evaluation procedure is the specification of criteria used in the selection of the high priority pollutant at each step of the standard-setting algorithm. Of the several

Table 4-11. Carbon Monoxide Priority Strategy Summary[a]

			Maximum Emission Rate		1985		1990		
	Priority Strategy[b,c]	Standard Setting Rate (no./yr)	(10^6 tpy)	(yr)	Emissions (10^6 tpy)	% Change from 1975	Emissions (10^6 tpy)	% Change from 1975	Efficiency Ratio (%)[d]
1.	State standards only		62.47	1990	53.46	+ 35.83	62.47	+ 58.7	- 54.7
2.	Only existing NSPS and state standards		50.96	1990	46.32	+ 17.7	50.96	+ 29.5	0.
3.	All NSPS set in 1975		39.36	1975	33.03	- 16.1	29.92	- 24.0	100.
4.	NSPS set in Ts-Tn order	2	39.75	1976	35.97	- 8.6	32.89	- 16.4	85.9
5.	Postpone constraint groups (UN/EQ/UGF/MCR/RD)	2	39.75	1976	37.30	- 5.2	35.19	- 10.6	75.0
6.	Postpone constraint groups (UN/EQ/UGF/MCR/RD)	10	39.65	1975	34.33	- 12.8	31.22	- 20.7	93.8

[a] Stationary sources only.

[b] All strategies exclude standards for group with no demonstrated control technology (NC). The unconstrained (UN) group includes all sources in Ts-Tn order unless a specific constraint is involved.

[c] Except for Strategy 1, all strategies assume existing NSPS to be in effect in 1975. Except for Strategies 1-4, all revised NSPS are subject to at least a 5-year delay in addition to other constraints that may be involved in the revision.

[d] Computed from the formula $[(E_2 - E_{strategy}) / (E_2 - E_3)]_{1990} \times 100\%$; i.e., Eqn. 3-15 where E_2 (Strategy 2) is E_{max} and E_3 (Strategy 3) is E_{min}.

possible criteria that could be used, the selection of the high priority pollutant for this study is based on a determination of the maximum of the lowest possible future emissions for each pollutant. That maximum value relative to the criteria emission level specified for the pollutant is the basis for selecting the priority pollutant.

When devising a combined strategy for all pollutants, the possibility of simultaneously setting standards for more than one pollutant for a given source category must be considered. In this study, it was assumed that if a control device or process change required to control the priority pollutant for a category resulted in the control of additional pollutants, standards for the additional pollutants were set simultaneously. Categories and pollutants with potential for multiple standards on the basis of the above assumption are identified in Table 4-12. These multiple pollutant standards resulted primarily from (a) use of scrubbers to control gaseous pollutants resulting in particulate control, (b) use of afterburners to control both HC and CO, and (c) process changes controlling various combinations of pollutants. It was assumed that the priority pollutant required the normal resources (manpower, money, etc.) for standard development, but the additional pollutants required only 25% of the normal resources for a separate standard.

In the analysis of alternate combined pollutant strategies, except as noted, any standard requiring additional control technique research and development (RD) or fuel switching to natural gas, or other fuels with limited availability (FS), was restricted from promulgation before 1985. Similarly, any revisions of existing NSPS were not permitted prior to 1980. In the single pollutant analysis these categories were generally constrained to these limitations as an automatic result of their low priority with a fixed standard setting rate. However, in the combined analysis, the rate for any pollutant is variable and the above constraints must be explicitly included. From the discussions in Chapters 5 and 6, these constraints are reasonable; however, a more detailed future analysis should consider more exact constraint dates for the individual categories.

Within these constraints, the sequence of standard setting for each pollutant remains the same as that for the final strategy in the single pollutant evaluation, with the exception of deviations resulting from multipollutant standards for a category.

Table 4-12. Multiple Pollutant Standards

Category	Other Pollutants Controlled Simultaneously				
Controlled Priority Pollutant:	TSP	HC	SO_2	NO_x	CO
Boilers: $<0.3 \times 10^6$ Btu/hr		CO			HC
Boilers: $0.3-10 \times 10^6$ Btu/hr		CO			HC
Boilers: $10-250 \times 10^6$ Btu/hr		CO			HC
Boilers: $>250 \times 10^6$ Btu/hr		CO			HC
Mixed Fuel Boilers (Coal and Refuse)			TSP		
Mixed Fuel Boilers (Oil and Refuse)			TSP		
Auto Body Incineration		CO			HC
Pathological Incineration		CO			HC
Municipal Incineration		CO			HC
Industrial/Commercial Incineration		CO			HC
Internal Combustion Engines (Spark Ignition)		CO			HC
Internal Combustion Engines (Diesel and Dual Fuel)		CO			HC
Stationary Gas Turbines (Electric Utility)				CO	NO_x
Stationary Gas Turbines (Pipe Line)				CO	NO_x
Open Burning (Agricultural)		CO			HC
Orchard Heaters		CO			HC
Phthalic Anhydride (Oxylene Process)		CO			HC
Carbon Black (Furnace Process)		CO			HC
Acrylonitrile		CO			HC
Ethylene Dichloride (Oxychlorination)		CO			HC

Table 4-12 (Contd.)

Category	Other Pollutants Controlled Simultaneously				
Controlled Priority Pollutant:	TSP	HC	SO_2	NO_x	CO
Formaldehyde		CO			HC
Ammonia (Regenerator and CO Absorber)		CO			HC
Charcoal	a	a			a
Explosives (High)			TSP		
Explosives (Low)			TSP		
Maleic Anhydride (Benzene Oxidation)		CO			HC
Meat Smokehouses	a	a			a
Coffee Roasting	a	a		a	
Sugar Cane (Field Burning)		CO			HC
Deep Fat Frying	a	a			
Asphalt Roofing (Blowing)	a	a			a
Cement Plants (Kilns and Clinker Coolers)	a		a	a	
Fiberglass (Textile Processing)				CO	NO_x
Brick and Related Clay Products		CO			HC
Mineral Wool		CO			HC
Fiberglass Production (Wool Processing)		CO			HC
Primary Aluminum Smelters			TSP		
Iron and Steel Plants (Sintering)			TSP		
By-Product Coke Ovens		CO			HC
Secondary Lead (Blast Furnace)			TSP		
Secondary Lead (Reverb Furnace)			TSP		
Secondary Zinc (Sweating)		CO			HC

Table 4-12. (Contd.)

Category	Other Pollutants Controlled Simultaneously				
Controlled Priority Pollutant:	TSP	HC	SO_2	NO_x	CO
Secondary Magnesium Smelting		CO			HC
Refinery Fuel Gas (Sulfur Recovery)			TSP		
Crude Oil and Natural Gas Production (Sulfur Recovery)			TSP		
Wood Pulping (Kraft)		CO			HC

[a] All criteria pollutants emitted (TSP, HC, SO_2, NO_x, CO) are controlled simultaneously.

Except where noted, the time increment between the setting of standards was one-half year with 11 standards (with normal development resource requirements) set at each time, or 22 per year.

The alternative combined pollutant strategies considered are summarized in Table 4-13. For comparison, the first strategy assumes all NSPS are set in 1975 and that the emission level prescribed by the standard is zero (i.e., En=0). This is the maximum control case where all new sources have perfect controls. The emission pattern for this strategy, plotted on Fig. 4-9, represents the existing sources. Obsolescence diminishes the emissions at a steady rate for all pollutants. Over the 1975-1990 time period, SO_2 emissions decrease the most (67%) while CO emissions decrease the least (31%).

Also for comparison purposes, the second strategy is a composite of the final strategies from the single pollutant evaluations with a fixed standard setting rate for each. The projected emissions, relative to 1975, are plotted for each pollutant on Fig. 4-10.

In Strategy 3, Table 4-13, all projected NSPS are set in 1975, with the exception of FS or RD categories for which the standards are set in 1985. This strategy, which represents the maximum standard-setting rate, and thus the lowest possible emissions with non-zero standards, is not realistic but was included for comparative purposes. The projected relative emissions for this strategy are shown in Fig. 4-11. This optimal strategy shows that it is feasible to keep the point source emissions of TSP, HC, and CO from rising very far above their 1975 levels even at the maximum point. The SO_2 emissions, however, increase significantly (10.6%) but can be reduced below 1975 levels if fuel switching and improved technology can be introduced in 1985. For NO_x, emissions will increase significantly (47.4%) even with the 1985 introduction of new technology.

Strategy 4 was used as the baseline case for the combined pollutant evaluation. The emissions level criteria used for selecting the priority pollutant was no increase above 1975 levels, except for NO_x, which had a criteria level of 44.4% above 1975 levels, which is the minimum level for NO_x even with advanced technology (see Sec. 4.4). The result of this strategy is the standard-setting schedule given in Table 4-14 and the projected emissions shown in Fig. 4-12. In the initial period, standard setting for HC is emphasized to counteract the initial rapid increase in this pollutant without

Table 4-13. Combined Pollutant Strategy Summary[a]

Priority Strategy[b]	Pollutant	Emission Criteria (% Change from 1975)	Standard Setting Rate (no./yr)	Maximum Emission Rate		1985	1990	
				% Change from 1975	Year	% Change from 1975	% Change from 1975	Efficiency Ratio (%)[c]
1. All NSPS set in 1975 at zero emission rate (i.e., En=0).	TSP	-		0.0	1975	-30.6	-45.9	-
	SO_2	-		0.0	1975	-44.5	-66.7	-
	NO_x	-		0.0	1975	-37.5	-56.3	-
	HC	-		0.0	1975	-29.5	-44.3	-
	CO	-		0.0	1975	-20.9	-31.3	-
2. TSP Strategy 10	TSP	-	6	+ 0.5	1976	- 3.9	- 6.4	59.9
SO_2 Strategy 9	SO_2	-	4	+ 10.9	1985	+10.9	- 3.3	48.9
NO_x Strategy 8	NO_x	-	4	+ 51.5	1990	+32.6	+51.5	88.7
HC Strategy 11	HC	-	6	+ 5.8	1980	+ 5.4	+ 2.0	82.8
CO Strategy 5	CO	-	2	+ 1.0	1976	- 5.2	-10.6	75.0
3. All standards set in 1975, except FS and RD groups in 1985	TSP	-		+ 0.4	1975	- 7.8	-14.8	80.1
	SO_2	-		+ 10.6	1985	+10.6	- 4.0	49.7
	NO_x	-		+ 47.4	1990	+28.5	+47.4	95.3
	HC	-		+ 1.3	1976	- 2.1	- 6.2	90.5
	CO	-		0.0	1975	- 9.1	-17.0	86.9
4. Baseline Strategy	TSP	0.0	22	+ 2.9	1979	- 0.9	- 6.7	60.6
	SO_2	0.0		+ 11.8	1985	+11.8	- 2.8	48.3
	NO_x	+44.4		+ 52.4	1990	+33.5	+52.4	87.2
	HC	0.0		+ 3.2	1978	+ 1.2	- 2.1	86.6
	CO	0.0		+ 2.6	1979	- 1.9	- 9.0	71.9
5. Decrease TSP emission criteria	TSP	- 5.0	22	+ 0.4	1975	- 4.2	- 9.9	68.3
	SO_2	0.0		+ 13.7	1985	+13.7	- 0.9	46.1
	NO_x	+ 44.4		+ 56.2	1990	+37.3	+56.2	81.1
	HC	0.0		+ 6.4	1978	+ 4.4	+ 1.2	83.6
	CO	0.0		+ 4.2	1980	+ 0.3	- 6.8	67.9
6. Decrease HC emission criteria	TSP	0.0	22	+ 3.9	1980	+ 0.4	- 5.3	57.3
	SO_2	0.0		+ 14.1	1985	+14.1	- 0.5	45.5
	NO_x	+ 44.4		+ 57.7	1990	+38.7	+57.7	78.8
	HC	- 5.0		+ 2.7	1976	- 0.3	- 3.5	87.9
	CO	0.0		+ 2.9	1981	- 0.6	- 7.7	69.5
7. Decrease SO_2 emission criteria	TSP	0.0	22	+ 3.9	1980	+ 0.4	- 5.3	57.3
	SO_2	- 5.0		+ 10.6	1985	+10.6	- 4.0	49.7
	NO_x	+ 44.4		+ 55.3	1990	+36.3	+55.3	82.6
	HC	0.0		+ 5.3	1978	+ 3.1	- 0.2	84.8
	CO	0.0		+ 3.7	1980	- 0.3	- 7.3	68.8
8. Increase SO_2 emission criteria	TSP	0.0	22	+ 2.5	1978	- 1.5	- 7.2	61.2
	SO_2	+5.0		+ 14.4	1985	+14.4	- 0.2	45.1
	NO_x	+ 44.4		+ 52.4	1990	+33.5	+52.4	87.2
	HC	0.0		+ 2.9	1977	+ 0.5	- 2.7	87.2
	CO	0.0		+ 2.2	1979	- 2.6	- 9.6	73.1

Table 4-13 (Contd.)

Priority Strategy[b]	Pollutant	Emission Criteria (% Change from 1975)	Standard Setting Rate (no./yr)	Maximum Emission Rate		1985	1990	
				% Change from 1975	Year	% Change from 1975	% Change from 1975	Efficiency Ratio (%)[c]
9. Decrease NO_x emission criteria	TSP	0.0	22	+ 3.8	1980	+ 0.4	- 5.4	57.4
	SO_2	0.0		+ 12.9	1985	+ 12.9	- 1.3	46.5
	NO_x	+35.0		+ 51.3	1990	+ 32.5	+ 51.3	88.9
	HC	0.0		+ 4.8	1977	+ 2.3	- 0.9	85.5
	CO	0.0		+ 3.2	1980	- 0.7	- 8.0	69.7
10. Increase NO_x emission criteria	TSP	0.0	22	+ 2.5	1978	- 1.4	- 7.2	61.7
	SO_2	0.0		+ 11.7	1985	+ 11.7	- 2.9	48.5
	NO_x	+50.0		+ 57.2	1990	+ 38.2	+ 57.2	79.6
	HC	0.0		+ 2.7	1976	+ 0.8	- 2.4	86.9
	CO	0.0		+ 2.3	1978	- 2.7	- 9.7	73.3
11. Decrease CO emission criteria	TSP	0.0	22	+ 4.2	1980	+ 1.0	- 4.7	55.9
	SO_2	0.0		+ 13.1	1985	+ 13.1	- 1.5	46.7
	NO_x	+44.4		+ 54.6	1990	+ 35.6	+ 54.6	83.8
	HC	0.0		+ 4.9	1978	+ 3.0	- 0.3	84.9
	CO	- 5.0		0.0	1975	- 8.4	- 15.4	84.0
12. Change standard-setting rate								
a.	TSP	0.0	4	+ 18.5	1990	+ 10.2	+ 18.5	31.6
	SO_2	0.0		+ 14.6	1985	+ 14.6	+ 8.2	35.2
	NO_x	+44.4		+ 73.0	1990	+ 45.1	+ 73.0	54.2
	HC	0.0		+ 20.2	1990	+ 14.5	+ 20.2	65.9
	CO	0.0		+ 11.2	1990	+ 7.2	+ 11.2	34.2
b.	TSP	0.0	10	+ 6.6	1989	+ 6.1	+ 6.5	29.0
	SO_2	0.0		+ 12.7	1985	+ 12.7	- 1.8	47.1
	NO_x	+44.4		+ 53.8	1990	+ 34.8	+ 53.8	84.9
	HC	0.0		+ 6.7	1989	+ 6.1	+ 6.5	78.6
	CO	0.0		+ 6.5	1986	+ 5.9	+ 3.9	47.8
c.	TSP	0.0	18	+ 3.7	1979	+ 0.6	- 4.2	54.6
	SO_2	0.0		+ 12.2	1985	+ 12.2	- 2.4	47.9
	NO_x	+44.4		+ 52.6	1990	+ 33.7	+ 52.6	87.0
	HC	0.0		+ 4.0	1978	+ 2.2	- 0.8	85.4
	CO	0.0		+ 3.2	1981	+ 0.1	- 5.9	66.2
d.	TSP	0.0	26	+ 2.6	1978	- 1.5	- 7.7	62.9
	SO_2	0.0		+ 11.8	1985	+ 11.8	- 2.8	48.3
	NO_x	+44.4		+ 52.3	1990	+ 33.5	+ 52.3	87.3
	HC	0.0		+ 3.1	1977	+ 0.7	- 2.8	87.2
	CO	0.0		+ 2.3	1979	- 2.8	- 10.1	74.0

Table 4-13 (Contd.)

Priority Strategy[b]	Pollutant	Emission Criteria (% Change from 1975)	Standard Setting Rate (no./yr)	Maximum Emission Rate		1985	1990	
				% Change from 1975	Year	% Change from 1975	% Change from 1975	Efficiency Ratio (%)[c]
13. Delay FS and RD groups until after 1990	TSP	0.0	22	+ 2.9	1979	- 0.9	- 3.5	53.1
	SO_2	0.0		+ 22.6	1990	+ 11.8	+ 22.6	18.1
	NO_x	+44.4		+ 53.0	1990	+ 33.5	+ 53.0	86.3
	HC	0.0		+ 3.2	1978	+ 1.2	+ 1.5	83.3
	CO	0.0		+ 2.6	1979	- 1.9	- 6.7	67.7
14. Time between sets of standards increased to one year	TSP	0.0	22	+ 4.2	1980	+ 0.8	- 5.4	57.5
	SO_2	0.0		+ 13.0	1985	+ 13.0	- 1.6	46.8
	NO_x	+44.4		+ 55.6	1990	+ 36.8	+ 55.6	82.1
	HC	0.0		+ 4.7	1977	+ 2.6	- 0.6	85.2
	CO	0.0		+ 3.8	1981	- 0.3	- 7.4	68.9
15. Effect of new NSPS is delayed 2-1/2 years	TSP	0.0	22	+ 6.1	1982	+ 4.5	+ 1.0	42.2
	SO_2	0.0		+ 20.7	1987	+ 15.9	+ 13.5	28.9
	NO_x	+44.4		+ 64.3	1990	+ 45.0	+ 64.3	68.2
	HC	0.0		+ 11.1	1978	+ 9.5	+ 8.5	76.7
	CO	0.0		+ 6.0	1982	+ 3.6	- 1.8	58.5
16. Set standards for all pollutants for a given source category[d]								
a. Effort increment of .25 per pollutant standard	TSP	0.0	22	+ 1.9	1980	- 1.8	- 8.7	65.5
	SO_2	0.0		+ 12.1	1985	+12.1	- 2.5	48.0
	NO_x	+44.4		+ 52.4	1990	+33.5	+ 52.4	87.2
	HC	0.0		+ 3.5	1978	+ 1.2	- 2.4	86.8
	CO	0.0		+ 2.2	1979	- 3.3	- 10.6	75.1
b. Effort increment of .75 per pollutant standard	TSP	0.0	22	+ 2.1	1980	- 0.4	- 7.3	62.1
	SO_2	0.0		+ 12.2	1985	+12.2	- 2.3	47.7
	NO_x	+44.4		+ 52.7	1990	+33.8	+ 52.7	86.7
	HC	0.0		+ 4.0	1979	+ 2.3	- 1.1	85.6
	CO	0.0		+ 2.8	1981	- 1.2	- 8.3	70.7

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[a] Stationary sources only.

[b] All strategies exclude NC group and assume existing NSPS to be in effect in 1975.

[c] Definitions for separate pollutants are given in Tables 4-3, 4-5, 4-7, 4-9, and 4-11.

[d] Except for fuel switching and research and development constraints.

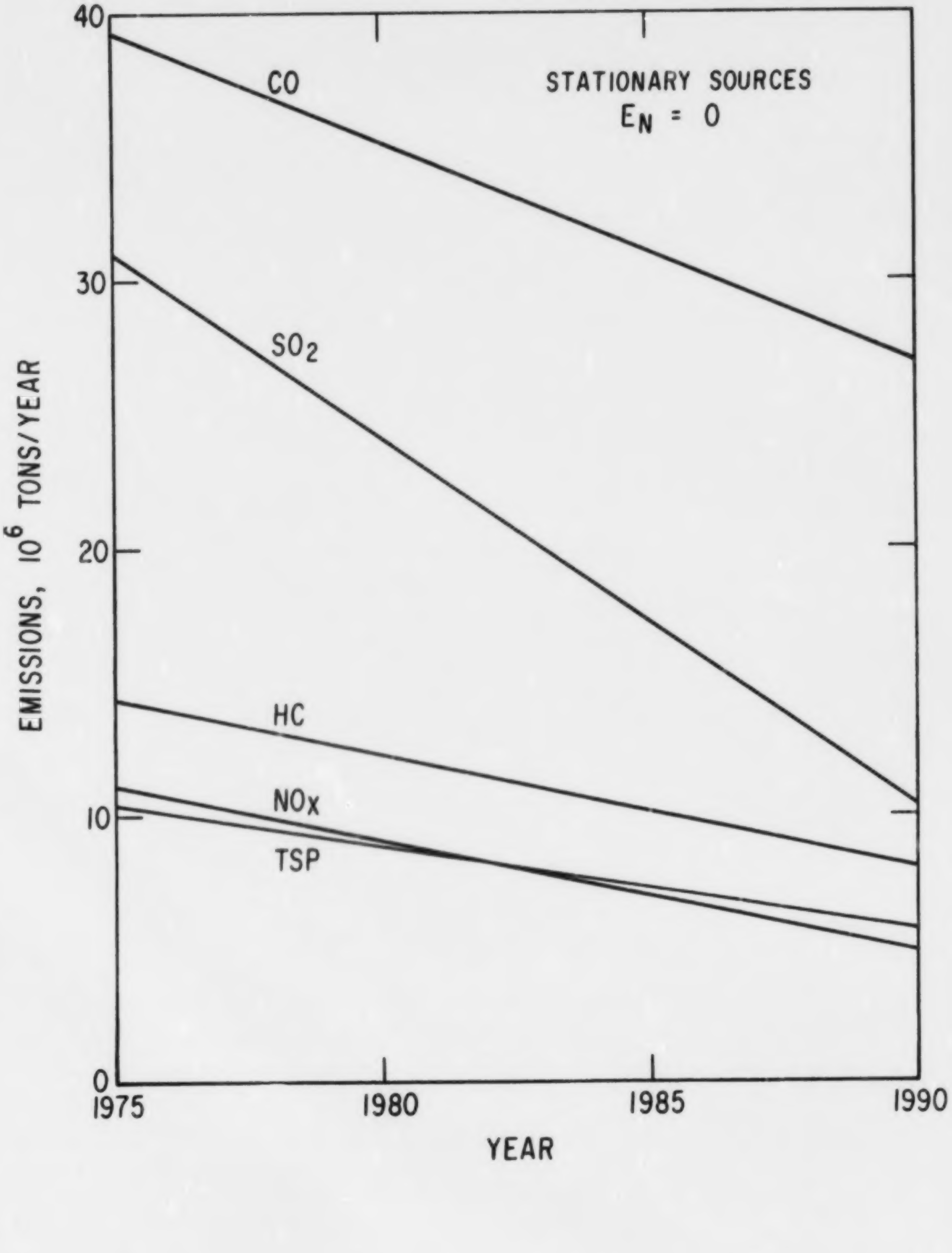

Fig. 4-9. Emission Projections for All NSPS Set at Zero Emissions

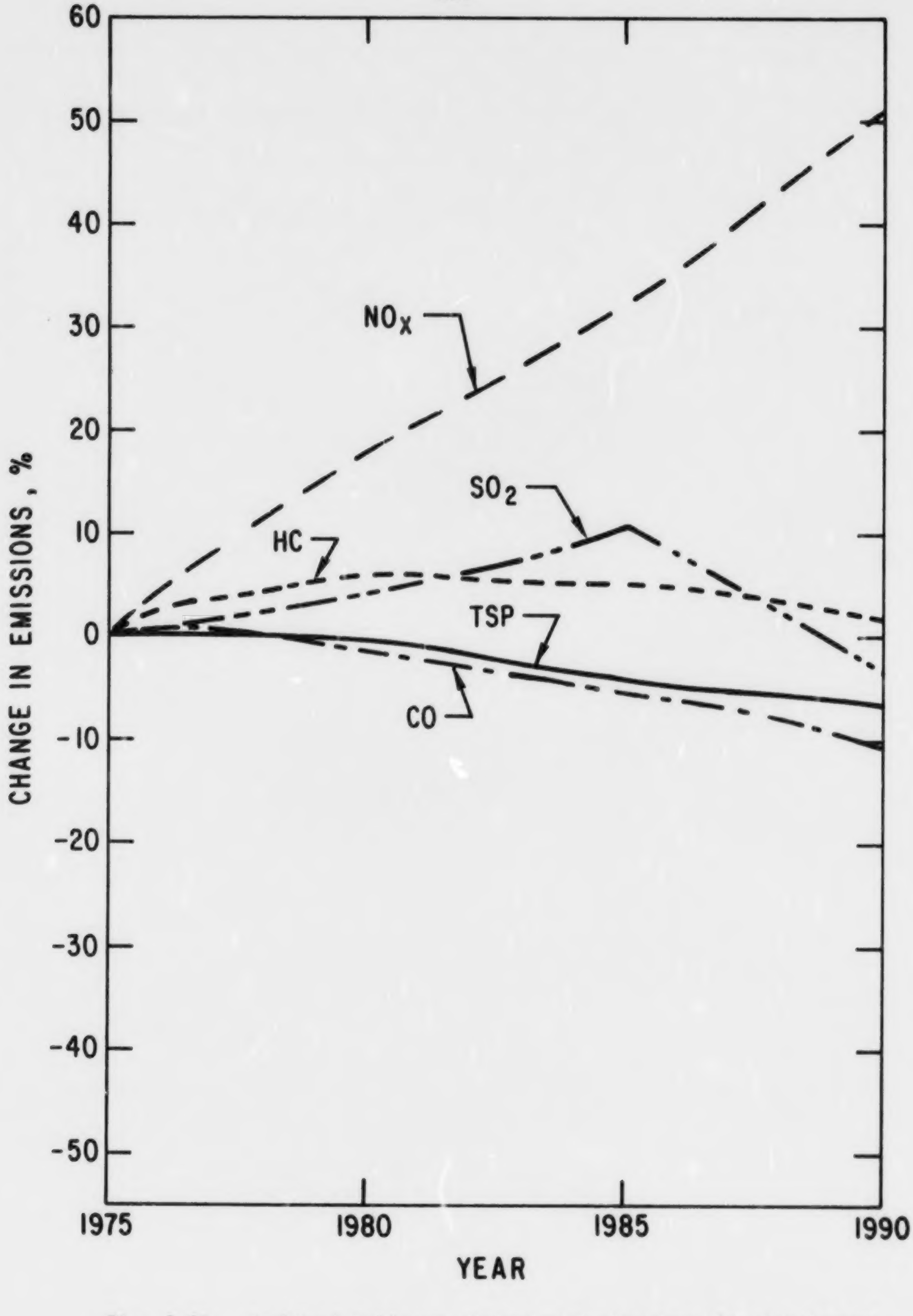

Fig. 4-10. Combined Pollutant Emission Projections for Stationary Sources Based on Single Pollutant Analysis (Strategy 2).

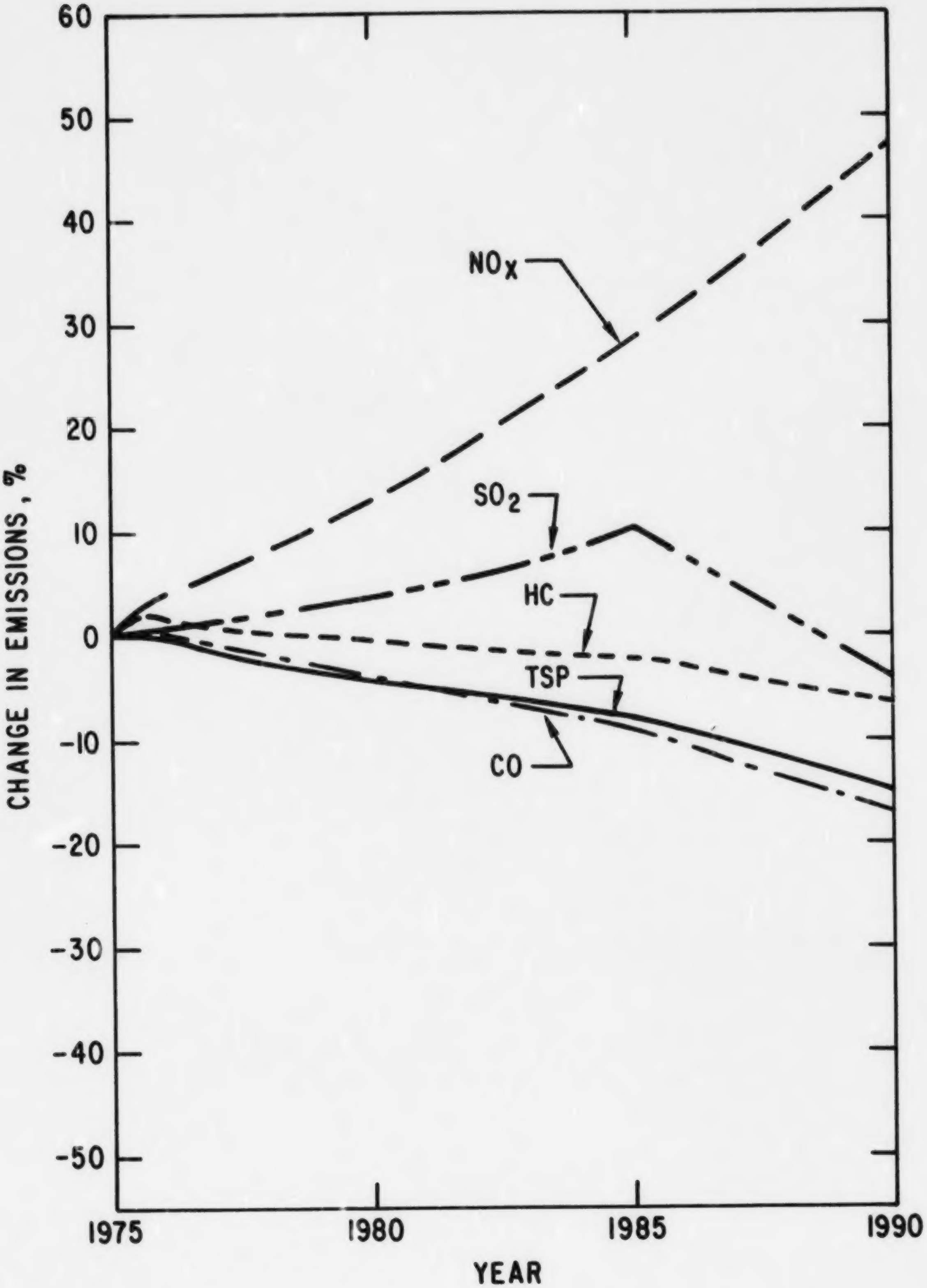

Fig. 4-11. Combined Pollutant Emission Projections for Stationary Sources Based on Setting All Feasible Standards Immediately (Strategy 3).

Table 4-14. Combined Pollutant Standard Setting Schedule for Baseline Strategy[a]

Year	Cumulative Effort	Pollutant	Standard Number[b]	Source
1975.0	1.00	PM	1	BOILERS (>250X10E6 BTU/HR)
	2.00	PM	0	BOILERS (10-250X10E6 BTU/HR)
	3.00	PM	1	ASPHALT BATCHING
	4.00	PM	1	IRON AND STEEL PLANTS (ELECTRIC ARC FURNACE)
	5.00	PM	0	COAL CLEANING (THERMAL DRYING)
	6.00	PM	1	CEMENT PLANTS (KILNS, CLINKER COOLERS)
	7.00	PM	1	PETROLEUM REFINERY (FCCU)
	8.00	PM	1	MUNICIPAL INCINERATORS
	9.00	PM	0	PRIMARY ZINC SMELTERS
	10.00	PM	1	BRASS AND BRONZE SMELTING
	11.00	PM	1	SECONDARY LEAD SMELTER (REVERBERATORY FURNACE)
	12.00	PM	0	PATHOLOGICAL INCINERATORS
	13.00	PM	1	SECONDARY LEAD SMELTER (BLAST FURNACE)
	14.00	PM	1	SLUDGE INCINERATORS
	15.00	PM	1	IRON AND STEEL PLANTS (BOF)
	16.00	SO	1	BOILERS (>250X10E6 BTU/HR)
	17.00	SO	0	BOILERS (10-250X10E6 BTU/HR)
	18.00	SO	0	PRIMARY COPPER SMELTERS
	19.00	SO	0	PRIMARY ZINC SMELTERS
	20.00	SO	0	CEMENT PLANTS (KILNS, CLINKER COOLERS)
	21.00	SO	1	SULFURIC ACID
	22.00	SO	0	COAL CLEANING (THERMAL DRYING)
	23.00	SO	0	ASPHALT BATCHING
	24.00	SO	1	PETROLEUM REFINERY (PROCESS GAS COMBUSTION)
	25.00	NO	1	BOILERS (>250X10E6 BTU/HR)
	26.00	NO	0	BOILERS (10-250X10E6 BTU/HR)
	27.00	NO	1	NITRIC ACID (AIR OXIDATION)
	28.00	HC	1	AVIATION GAS STORAGE (WORKING)
	29.00	HC	1	AVIATION GAS STORAGE (BREATHING)
	30.00	HC	1	CRUDE OIL STORAGE (WORKING)
	31.00	HC	1	CRUDE OIL STORAGE (BREATHING)
	32.00	HC	1	GASOLINE STORAGE (WORKING)
	33.00	HC	1	GASOLINE STORAGE (BREATHING)
	34.00	HC	1	JET FUEL STORAGE (WORKING)
	35.00	HC	1	JET FUEL STORAGE (BREATHING)
	36.00	HC	1	SPECIAL NAPHTHA STORAGE (WORKING)
	37.00	HC	1	SPECIAL NAPHTHA STORAGE (BREATHING)
	38.00	CO	1	PETROLEUM REFINERY (FCCU)

Table 4-14. (Cont'd.)

Year	Cumulative Effort	Pollutant	Standard Number[b]	Source
1975.5	1.00	HC	1	SURFACE COATING (INDUSTRIAL)
	2.00	HC	1	AMMONIA - METHANATOR PLANT
	3.00	HC	1	AMMONIA - REGENERATOR AND CO ABSORBER
	3.25	CO	1	
	4.25	HC	1	DEGREASING
	4.75	NO	1	STATIONARY GAS TURBINES (ELECTRIC UTILITY)
	4.88	CO	1	
	5.88	HC	1	ETHYLENE OXIDE
	6.88	HC	1	CARBON BLACK (FURNACE PROCESS)
	7.13	CO	1	
	8.13	HC	1	CHARCOAL
	8.38	PM	1	
	8.63	CO	1	
	9.63	HC	1	GRAPHIC ARTS (GRAVURE)
	10.63	HC	1	BEER PROCESSING
	11.63	HC	1	VEGETABLE OIL MANUFACTURING
1976.0	1.13	NO	1	STATIONARY GAS TURBINES (PIPE LINE)
	1.25	CO	1	
	2.25	NO	1	STATIONARY INTERNAL COMBUSTION ENGINES (SPARK IGNITION)
	3.25	NO	1	BOILERS (10-250X10E6 BTU/HR)
	4.25	NO	1	EXPLOSIVES (HIGH)
	4.75	NO	1	BOILERS-MIXED FUEL (COAL AND REFUSE)
	5.25	NO	1	BOILERS-MIXED FUEL (OIL AND REFUSE)
	6.25	NO	1	STATIONARY INTERNAL COMBUSTION ENGINES (DIESEL AND DUAL FUEL)
	6.75	HC	1	DISTILLATE OIL STORAGE (BREATHING)
	7.25	HC	1	KEROSENE STORAGE (BREATHING)
	8.25	HC	1	SYNTHETIC RESIN (ACRYLIC)
	9.25	HC	1	FIBERS (NYLON)
	10.25	HC	1	WHISKEY PROCESSING
	11.25	HC	1	FIBERS (ACETATE)
1976.5	1.25	HC	1	TEXTILE PROCESSING (HEAT SETTING AND FINISHING)
	2.25	HC	1	TEXTILE PROCESSING (CARPET MANUFACTURING)
	3.25	HC	1	RUBBER (STYRENE - BUTADIENE)
	4.25	HC	1	LEAD ACID BATTERY ASSEMBLY PLANTS
	5.25	HC	1	SYNTHETIC RESIN (ALKYD)
	6.25	HC	1	TEXTILE PROCESSING (TEXTURIZING)
	7.25	HC	1	PETROLEUM REFINERY (MISC. POINT SOURCES)
	8.25	SO	1	PRIMARY COPPER SMELTERS
	9.25	NO	1	CEMENT PLANTS (KILNS, CLINKER COOLERS)
	9.50	SO	1	
	10.50	NO	1	MUNICIPAL INCINERATORS
	11.50	NO	1	ADIPIC ACID

Table 4-14. (Cont'd.)

Year	Cumulative Effort	Pollutant	Standard Number^b	Source
1977.0				
	1.50	NO	1	DMT/TPA (NITRIC ACID OXIDE)
	2.50	NO	1	FIBERGLASS (WOOL)
	3.50	NO	1	BOILERS (0.3-10X10E6 BTU/HR)
	4.50	NO	1	INDUSTRIAL/COMMERCIAL INCINERATORS
	5.50	NO	1	EXPLOSIVES (LOW)
	6.50	NO	1	AUTO BODY INCINERATORS
	7.50	SO	1	PRIMARY ZINC SMELTERS
	8.50	HC	1	REFUELING MOTOR VEHICLES
	9.50	SO	1	PRIMARY LEAD SMELTERS
	10.50	SO	1	WOOD PULPING (NSSC)
	11.50	SO	1	WOOD PULPING (SULFITE)
1977.5				
	1.50	SO	1	WOOD PULPING (KRAFT PROCESS)
	2.50	SO	1	LIME PROCESSING
	3.50	SO	1	FIBERGLASS (TEXTILE)
	4.50	SO	1	FIBERGLASS (WOOL)
	5.50	SO	1	BOILERS-MIXED FUEL (COAL AND REFUSE)
	5.75	PM	1	
	6.75	SO	1	EXPLOSIVES (HIGH)
	7.00	PM	1	
	8.00	SO	1	SECONDARY LEAD SMELTER (REVERBERATORY FURNACE)
	9.00	SO	1	EXPLOSIVES (LOW)
	10.00	SO	1	SULFUR RECOVERY (REFINERY FUEL GAS)
	11.00	SO	1	SULFUR RECOVERY (CRUDE OIL AND NATURAL GAS PRODUCTION)
1978.0				
	1.00	HC	1	DRY CLEANING
	2.00	HC	1	SERVICE STATIONS
	2.20	HC	1	GASOLINE TRANSFER
	2.40	HC	1	CRUDE OIL TRANSFER
	2.60	HC	1	JET FUEL TRANSFER
	2.80	HC	1	AVIATION GAS TRANSFER
	3.00	HC	1	SPECIAL NAPHTHA TRANSFER
	4.00	HC	1	DIRECT FIRING OF MEATS
	5.00	HC	1	STATIONARY INTERNAL COMBUSTION ENGINES (DIESEL AND DUAL FUEL)
	5.25	CO	1	
	6.25	HC	1	PATHOLOGICAL INCINERATORS
	6.50	CO	1	
	7.50	HC	1	GRAPHIC ARTS (FLEXOGRAPHY)
	8.50	HC	1	PETROLEUM REFINERY (VACUUM DISTILLATION)
	9.50	HC	1	GRAPHIC ARTS (LETTER PRESS)
	10.50	HC	1	GRAPHIC ARTS (LITHOGRAPHY)
	11.50	HC	1	GRAPHIC ARTS (METAL DECORATING)

Table 4-14. (Cont'd.)

Year	Cumulative Effort	Pollutant	Standard Number[b]	Source
1978.5				
	1.50	PM	1	BOILERS (10-250X10E6 BTU/HR)
	3.50	PM	1	GRAIN MILLING AND STORAGE (PROCESSING)
	4.50	HC	1	CAST IRON FOUNDRY (CORE OVENS)
	5.50	PM	1	STONE QUARRYING AND PROCESSING
	6.50	HC	1	PAINT
	7.50	HC	1	POLYETHYLENE (LOW DENSITY)
	8.00	PM	1	GRAIN MILLING AND STORAGE (TRANSFER)
	9.00	HC	1	MALEIC ANHYDRIDE (BENZENE OXIDATION)
	9.25	CO	1	
	10.25	HC	1	POLYETHYLENE (HIGH DENSITY)
	11.25	HC	1	VARNISH
1979.0				
	1.75	PM	1	INDUSTRIAL/COMMERCIAL INCINERATORS
	2.25	PM	1	GRAIN MILLING AND STORAGE (SCREENING AND CLEANING)
	3.25	PM	1	BOILERS-WOOD WASTE
	4.25	PM	1	BYPRODUCT COKE OVENS
	5.25	PM	1	LIME PROCESSING
	6.25	PM	1	STEEL FOUNDRIES
	7.25	PM	1	CAST IRON FOUNDRY (ELECTRIC FURNACE)
	8.25	PM	1	PRIMARY COPPER SMELTERS
	9.25	PM	1	PLYWOOD VENEER PROCESSING
	10.25	PM	1	SAND AND GRAVEL
	11.25	PM	1	PRIMARY ALUMINUM SMELTERS
1979.5				
	1.25	CO	1	IRON AND STEEL PLANTS (BOF)
	2.25	PM	1	WHISKEY PROCESSING
	3.25	PM	1	VEGETABLE OIL MANUFACTURING
	4.25	PM	1	PHOSPHATE ROCK (GRINDING)
	5.25	PM	1	CONCRETE BATCHING
	6.25	PM	1	NITRATE FERTILIZER
	7.25	PM	1	COAL CLEANING (THERMAL DRYING)
	7.75	PM	1	GRAIN MILLING AND STORAGE (DRYING)
	8.75	PM	1	BEER PROCESSING
	9.75	PM	1	FEED MILLING AND STORAGE (OTHER)
	10.75	PM	1	DEEP FAT FRYING
	11.00	HC	1	

Table 4-14. (Cont'd.)

Year	Cumulative Effort	Pollutant	Standard Number[b]	Source
1980.0				
	1.00	NO	2	BOILERS (>250X10E6 BTU/HR)
	2.00	NO	2	NITRIC ACID (AIR OXIDATION)
	3.00	PM	2	BOILERS (>250X10E6 BTU/HR)
	4.00	HC	1	PHTHALIC ANHYDRIDE (O-XYLENE)
	4.25	CO	1	
	5.25	HC	1	POLYVINYL CHLORIDE
	6.25	HC	1	PRINTING INK
	7.25	HC	1	PLYWOOD VENEER PROCESSING
	8.25	HC	1	POLYSTYRENE
	9.25	HC	1	RESINS (PHENOLIC)
	10.25	HC	1	ASPHALT ROOFING (BLOWING)
	10.50	PM	1	
	10.75	CO	1	
	11.75	HC	1	MINERAL WOOL PROCESSING
	12.00	CO	1	
1980.5				
	2.00	HC	1	RESINS (UREA-MELAMINE)
	3.00	HC	1	FIBERGLASS (WOOL)
	3.25	CO	1	
	4.25	HC	1	RESINS (ABS-SAN)
	5.25	HC	1	POLYPROPYLENE
	6.25	HC	1	COFFEE ROASTING
	6.50	PM	1	
	7.50	HC	1	AUTO BODY INCINERATORS
	7.75	CO	1	
	8.75	HC	1	SECONDARY ZINC (SWEATING)
	9.00	CO	1	
	10.00	HC	1	MEAT SMOKEHOUSES
	10.25	PM	1	
	10.50	CO	1	
	11.50	HC	1	SECONDARY MAGNESIUM SMELTING
	11.75	CO	1	
1981.0				
	1.75	HC	1	ACRYLONITRILE
	2.00	CO	1	
	3.00	HC	1	FORMALDEHYDE
	3.25	CO	1	
	4.25	HC	1	ETHYLENE DICHLORIDE
	4.50	CO	1	
	5.50	PM	2	ASPHALT BATCHING
	6.50	PM	2	IRON AND STEEL PLANTS (ELECTRIC ARC FURNACE)
	8.50	PM	1	FERROALLOY (ESA FURNACE)
	9.50	PM	1	SYNTHETIC RESINS (POLYESTER)
	10.50	PM	1	POLYPROPYLENE
	11.50	PM	1	SODIUM CARBONATE (NATURAL)

Table 4-14. (Cont'd.)

Year	Cumulative Effort	Pollutant	Standard Number[b]	Source
1981.5	1.50	PM	1	COTTON GINNING
	2.50	PM	1	CERAMIC CLAY
	3.50	PM	1	FIBERS (DACRON)
	4.50	PM	2	PETROLEUM REFINERY (FCCU)
	5.50	PM	1	POLYVINYL CHLORIDE
	6.50	PM	2	SECONDARY LEAD SMELTER (REVERBERATORY FURNACE)
	7.50	PM	2	SECONDARY LEAD SMELTER (BLAST FURNACE)
	8.50	PM	1	BRICK AND RELATED CLAY PRODUCTS
	9.50	PM	1	AMMONIUM SULFATE FERTILIZER
	10.50	PM	1	IRON AND STEEL PLANTS (SINTERING)
	11.50	PM	1	PHOSPHATE ROCK (DRYING/HANDLING)
1982.0	1.50	PM	1	GYPSUM PROCESSING
	2.50	PM	1	DIAMMONIUM PHOSPHATE FERTILIZER
	3.50	PM	1	SUGAR CANE PROCESSING (BAGASSE BURNING)
	4.50	PM	1	ASPHALT ROOFING (SATURATOR)
	5.50	PM	1	IRON AND STEEL PLANTS (SCARFING AND ROLLING MILL COAL COMBUSTION)
	6.50	PM	1	STARCH MANUFACTURING
	7.50	PM	1	PAINT
	8.50	PM	1	SECONDARY ALUMINUM PRODUCTION (REVERBERATORY FURNACE)
	9.50	PM	1	SECONDARY COPPER (SMELTING AND REFINING)
	11.00	PM	1	SECONDARY COPPER (MATERIAL HANDLING)
1982.5	1.00	PM	1	FIBERS (NYLON)
	2.00	PM	1	FEED MILLING AND STORAGE (ALFALFA DEHYDRATING)
	3.00	PM	1	PETROLEUM REFINERY (PROCESS GAS COMBUSTION)
	4.00	PM	1	MINERAL WOOL PROCESSING
	5.00	PM	1	LEAD ACID BATTERY ASSEMBLY PLANTS
	6.00	PM	1	FLYASH SINTERING
	7.00	PM	1	FRIT PROCESSING
	8.00	PM	1	PHOSPHORIC ACID (THERMAL PROCESS)
	9.00	PM	1	PULPBOARD PROCESSING
	10.00	PM	1	PHOSPHATE ROCK (CALCINING)
	11.00	PM	1	PERLITE PROCESSING

Table 4-14. (Cont'd.)

Year	Cumulative Effort	Pollutant	Standard Number[b]	Source
1983.0				
	1.00	PM	1	AUTO BODY INCINERATORS
	2.00	PM	1	CARBON BLACK (FURNACE PROCESS)
	3.00	PM	1	DETERGENT (SPRAY DRIED)
	4.00	PM	1	GRANULATED TRIPLE SUPERPHOSPHATE FERTILIZER (STORAGE)
	5.00	PM	1	SECONDARY ALUMINUM PRODUCTION (SWEAT FURNACE)
	6.00	PM	1	CLAY SINTERING
	7.00	PM	1	MINING AND MILLING OF LEAD ORE
	8.00	PM	1	PRIMARY LEAD SMELTERS
	9.00	PM	1	PRIMARY ZINC SMELTERS
	10.00	PM	1	SECONDARY ZINC (SWEATING)
	11.00	PM	1	ANIMAL FEED DEFLUORINATION
1983.5				
	1.00	PM	1	RUBBER (STYRENE - BUTADIENE)
	2.00	PM	1	SECONDARY ZINC (DISTILLATION)
	3.00	PM	1	CASTABLE REFRACTORY
	4.00	PM	1	SOAP
	5.00	PM	1	SECONDARY LEAD SMELTER (POT FURNACE)
	6.00	PM	1	SECONDARY MAGNESIUM SMELTING
	7.00	PM	1	FISH PROCESSING (FISH MEAL COOKERS AND DRIERS)
	8.00	PM	1	DIRECT FIRING OF MEATS
	9.00	PM	1	PATHOLOGICAL INCINERATORS
	10.00	CO	1	WOOD PULPING (KRAFT PROCESS)
	11.00	CO	1	IRON AND STEEL PLANTS (ELECTRIC ARC FURNACE)
1984.0				
	1.00	CO	1	IRON AND STEEL PLANTS (BLAST FURNACE)
	2.00	CO	1	FERROALLOY (ESA FURNACE)
	3.00	CO	1	SECONDARY LEAD SMELTER (BLAST FURNACE)
1984.5				
1985.0				
	1.00	SO	2	BOILERS (>250X10E6 BTU/HR)
	2.00	SO	1	BOILERS (10-250X10E6 BTU/HR)
	3.00	SO	1	BOILERS (0.3-10X10E6 BTU/HR)
	4.00	SO	1	BOILERS (<0.3X10E6 BTU/HR)
	4.50	SO	1	STATIONARY GAS TURBINES (ELECTRIC UTILITY)
	5.00	SO	1	STATIONARY GAS TURBINES (PIPE LINE)
	6.00	SO	1	COAL CLEANING (THERMAL DRYING)
	7.00	SO	1	STATIONARY INTERNAL COMBUSTION ENGINES (DIESEL AND DUAL FUEL)
	8.00	SO	1	BRICK AND RELATED CLAY PRODUCTS
	9.00	SO	1	ASPHALT BATCHING
	10.00	SO	1	BOILERS-MIXED FUEL (OIL AND REFUSE)
	10.25	PM	1	
	11.25	SO	2	SULFURIC ACID

Table 4-14. (Cont'd.)

Year	Cumulative Effort	Pollutant	Standard Number^b	Source
1985.5				
	1.25	SO	1	SECONDARY LEAD SMELTER (BLAST FURNACE)
	2.25	NO	1	BOILERS (<0.3X10E6 BTU/HR)
	3.25	NO	1	GLASS (SODA-LIME)
	4.25	NO	1	PETROLEUM REFINERY (PROCESS GAS COMBUSTION)
	5.25	NO	1	FIBERGLASS (TEXTILE)
	5.50	CO	1	
	6.50	NO	1	LIME PROCESSING
	7.50	NO	1	BRICK AND RELATED CLAY PRODUCTS
	8.50	NO	1	CERAMIC CLAY
	9.50	NO	1	NITRATE FERTILIZER
	10.50	NO	1	BYPRODUCT COKE OVENS
	11.50	NO	1	PATHOLOGICAL INCINERATORS
1986.0				
	1.50	NO	1	GLASS (OPAL)
	2.50	NO	1	MINERAL WOOL PROCESSING
	3.50	NO	1	COFFEE ROASTING
	4.50	HC	1	STATIONARY INTERNAL COMBUSTION ENGINES (SPARK IGNITION)
	4.75	CO	1	
	5.75	HC	1	BOILERS (>250X10E6 BTU/HR)
	6.00	CO	1	
	7.00	HC	1	BOILERS (0.3-10X10E6 BTU/HR)
	7.25	CO	1	
	8.25	HC	1	BOILERS (10-250X10E6 BTU/HR)
	8.50	CO	1	
	9.50	HC	1	BYPRODUCT COKE OVENS
	9.75	CO	1	
	10.75	HC	1	AUTOMOBILE ASSEMBLY PLANTS
	11.75	HC	1	INDUSTRIAL/COMMERCIAL INCINERATORS
	12.00	CO	1	
1986.5				
	2.00	HC	1	BOILERS (<0.3X10E6 BTU/HR)
	2.25	CO	1	
	3.25	HC	1	ASPHALT BATCHING
	4.25	HC	1	MUNICIPAL INCINERATORS
	4.50	CO	1	
	5.50	PM	1	BOILERS (0.3-10X10E6 BTU/HR)
	6.50	PM	1	BOILERS (<0.3X10E6 BTU/HR)
	7.00	PM	1	STATIONARY GAS TURBINES (ELECTRIC UTILITY)
	7.50	PM	1	STATIONARY GAS TURBINES (PIPE LINE)
	8.50	PM	1	STATIONARY INTERNAL COMBUSTION ENGINES (DIESEL AND DUAL FUEL)
	9.50	PM	1	GLASS (SODA-LIME)
	10.50	PM	2	CEMENT PLANTS (KILNS, CLINKER COOLERS)
	11.50	PM	2	MUNICIPAL INCINERATORS

Table 4-14. (Cont'd.)

Year	Cumulative Effort	Pollutant	Standard Number[b]	Source
1987.0	1.50	PM	1	FIBERGLASS (TEXTILE)
	2.50	PM	1	GLASS (OPAL)
	3.50	PM	2	BRASS AND BRONZE SMELTING
	4.50	CO	1	IRON AND STEEL PLANTS (SINTERING)
1987.5				
1988.0				
1988.5				
1989.0				
1989.5				

[a] Strategy 4, Table 4-13.

[b] Existing standards assumed to be in effect in 1975. Standard No. 0 implies a state standard for new sources, No. 1 implies the first federal NSPS, No. 2 implies a revised federal NSPS.

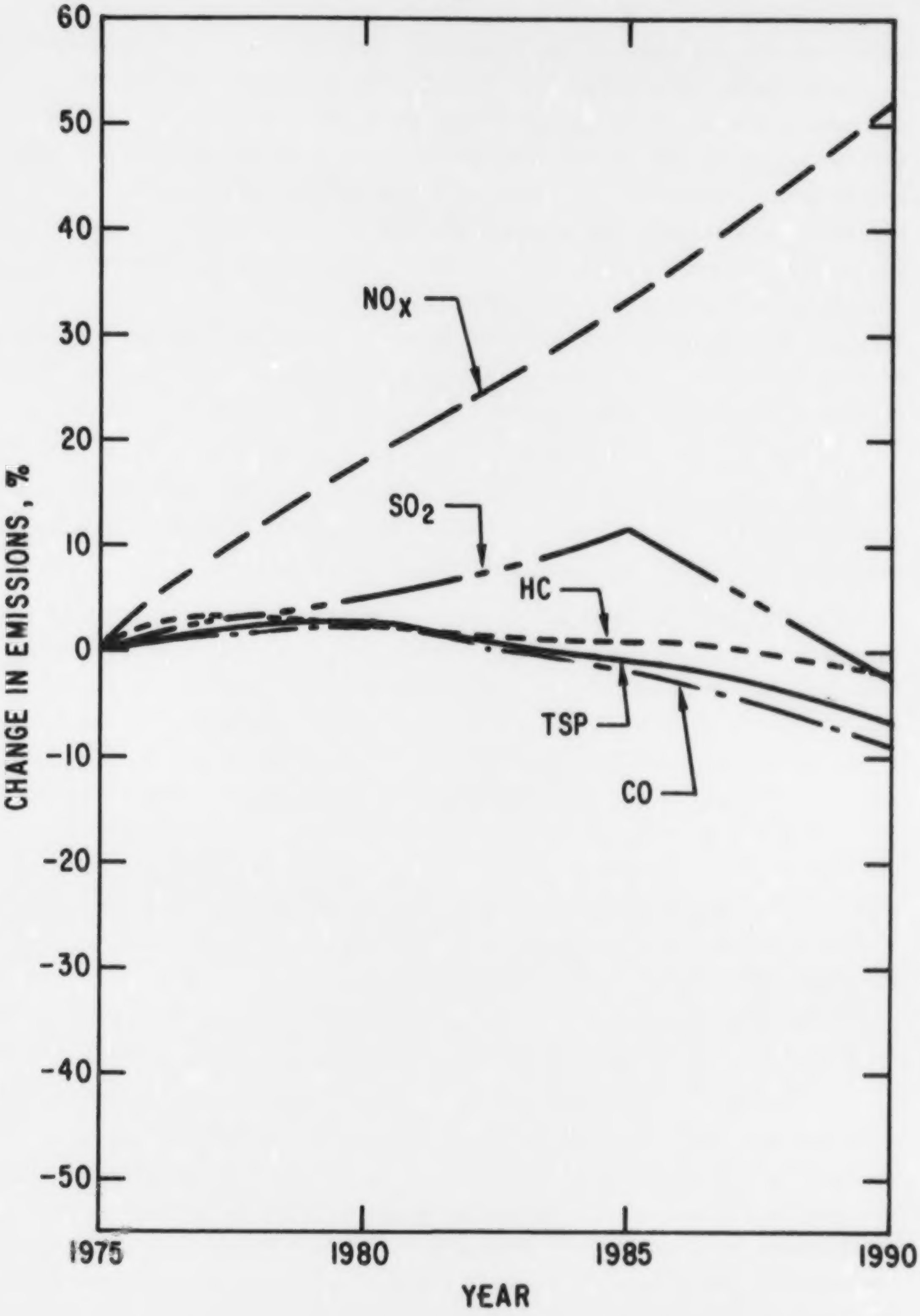

Fig. 4-12. Combined Pollutant Emission Projections for Stationary Sources Using Baseline Strategy (Strategy 4).

additional NSPS as shown in the Strategy 2 curve of Fig. 4-5. The second pollutant emphasized is NO_x. Although NO_x emissions have the most rapid increase initially, their increase relative to the criteria of 44.4% above 1975 emissions is not greater than the relative HC emission increase. The growth in SO_2 emissions cause this to be the priority pollutant by 1977 after the major unconstrained NO_x sources have been regulated. All unconstrained SO_2 source standards precede the particulate standards. In summary, the sequential emphasis on pollutant standards for Strategy 4 is HC, NO_x, SO_2, TSP, and CO, although other pollutant standards were set during the emphasis of each pollutant. The standards for CO result in large part through simultaneous promulgation with HC or NO_x.

The baseline Strategy 4, in comparison to Strategy 2 using individual pollutant evaluations, produces a more nearly equivalent, relative maximum emission for TSP, HC, and CO, of about 3% increase over 1975 emissions. The maximum emissions for SO_2, NO_x, and CO increase slightly.

The baseline Strategy 4 results in a standard-setting schedule and emissions reductions that is nearly optimal given the pollutant criteria, total standard-setting rate, and other constraints. However, as the goals and objectives of NSPS change as the result of, for example, new information on the health effects of certain pollutants, new technology, increased availability of "clean fuels," and changes in impact of complementary SIP or mobile source strategies, alternative standard-setting schedules for NSPS may be preferable. In fact, the real value of the methodology developed in this study is not only the ability to specify a future NSPS schedule, but to give alternate schedules on the basis of a variety of conditions or goals. Strategies 5-11 in Table 4-13 summarize a sensitivity analysis on the effects of individually increasing or decreasing the criteria or goal for each of the pollutants, and Strategies 12-15 show the effect of changes in other constraints.

Decreasing or increasing the emission criteria separately for each pollutant did have the expected effect of a corresponding increase or decrease in the maximum and final emission level for that pollutant. There is, however, a limit to the change in projected emission level that is achievable as indicated by Strategy 3 in which all standards are set in 1975, or 1985 if constrained. An attempt to obtain increased reductions by lowering the criteria can result in overemphasis of that pollutant with minor benefits at the expense of increased emissions for other pollutants. For example, a criteria of 5% reduction from 1975 emissions for SO_2 (Strategy 7) resulted in only a 1.2% reduction in SO_2 maximum emissions (compared to Strategy 4) while increasing the relative NO_x emissions by almost 3 percentage points and HC by more than 2 percentage points.

Although the change in emissions due to change in criteria may be small, the change is usually obtained as a result of major changes in NSPS development schedules. For each of the decreases in emission criteria shown on the table, that pollutant became the initial priority pollutant in 1975. Similarly, relaxing of the SO_2 criteria (Strategy 8) resulted in delay of the emphasis on SO_2 control until after a significant number of HC, NO_x, and TSP standards had been set, and relaxing the NO_x criteria (Strategy 10) delayed the majority of NO_x standards until near the completion of HC and SO_2 standard-setting.

The most likely alternative to the baseline Strategy 4 is Strategy 9, which has a lower criteria for NO_x. The standard-setting schedule that resulted from this change are given in Table 4-15 and the projected emissions are illustrated in Fig. 4-13.

Strategy 12 was developed using the Strategy 4 baseline emissions criteria but with standard-setting rates of 4, 10, 18 and 26 per year. The 1990 emissions are plotted as a function of standard-setting rate on Fig. 4-14. It is evident that the rate at which standards are set has only minimal impact on the end period emissions beyond a pace of about 10 per year. This indicates that the order of standard-setting is much more significant than the rate. Once the large sources are controlled, standards for the many smaller sources will provide relatively small reductions. However, while the change in projected national emissions is not large, the impact on selected geographic areas may be significant.

The possibility of no new technology or of no increase in availability of clean fuels before 1990 is simulated in Strategy 13. There is a major impact on 1990 emissions of SO_2 with this assumption with the increase from 1975 levels going from -2.8% for the baseline Strategy 4 to +22.6% with this assumption.

Table 4-15. Combined Pollutant Standard Setting Schedule for Strategy with NO_x Emphasis[a]

Year	Cumulative Effort	Pollutant	Standard Number[b]	Source
1975.0				
	1.00	PM	1	BOILERS (>250X10E6 BTU/HR)
	2.00	PM	0	BOILERS (10-250X10E6 BTU/HR)
	3.00	PM	1	ASPHALT BATCHING
	4.00	PM	1	IRON AND STEEL PLANTS (ELECTRIC ARC FURNACE)
	5.00	PM	0	COAL CLEANING (THERMAL DRYING)
	6.00	PM	1	CEMENT PLANTS (KILNS, CLINKER COOLERS)
	7.00	PM	1	PETROLEUM REFINERY (FCCU)
	8.00	PM	1	MUNICIPAL INCINERATORS
	9.00	PM	0	PRIMARY ZINC SMELTERS
	10.00	PM	1	BRASS AND BRONZE SMELTING
	11.00	PM	1	SECONDARY LEAD SMELTER (REVERBERATORY FURNACE)
	12.00	PM	0	PATHOLOGICAL INCINERATORS
	13.00	PM	1	SECONDARY LEAD SMELTER (BLAST FURNACE)
	14.00	PM	1	SLUDGE INCINERATORS
	15.00	PM	1	IRON AND STEEL PLANTS (BOF)
	16.00	SO	1	BOILERS (>250X10E6 BTU/HR)
	17.00	SO	0	BOILERS (10-250X10E6 BTU/HR)
	18.00	SO	0	PRIMARY COPPER SMELTERS
	19.00	SO	0	PRIMARY ZINC SMELTERS
	20.00	SO	0	CEMENT PLANTS (KILNS, CLINKER COOLERS)
	21.00	SO	1	SULFURIC ACID
	22.00	SO	0	COAL CLEANING (THERMAL DRYING)
	23.00	SO	0	ASPHALT BATCHING
	24.00	SO	1	PETROLEUM REFINERY (PROCESS GAS COMBUSTION)
	25.00	NO	1	BOILERS (>250X10E6 BTU/HR)
	26.00	NO	0	BOILERS (10-250X10E6 BTU/HR)
	27.00	NO	1	NITRIC ACID (AIR OXIDATION)
	28.00	HC	1	AVIATION GAS STORAGE (WORKING)
	29.00	HC	1	AVIATION GAS STORAGE (BREATHING)
	30.00	HC	1	CRUDE OIL STORAGE (WORKING)
	31.00	HC	1	CRUDE OIL STORAGE (BREATHING)
	32.00	HC	1	GASOLINE STORAGE (WORKING)
	33.00	HC	1	GASOLINE STORAGE (BREATHING)
	34.00	HC	1	JET FUEL STORAGE (WORKING)
	35.00	HC	1	JET FUEL STORAGE (BREATHING)
	36.00	HC	1	SPECIAL NAPHTHA STORAGE (WORKING)
	37.00	HC	1	SPECIAL NAPHTHA STORAGE (BREATHING)
	38.00	CO	1	PETROLEUM REFINERY (FCCU)

Table 4-15. (Cont'd.)

Year	Cumulative Effort	Pollutant	Standard Number[b]	Source
1975.5	0.50	NO	1	STATIONARY GAS TURBINES (ELECTRIC UTILITY)
	0.63	CO	1	
	1.13	NO	1	STATIONARY GAS TURBINES (PIPE LINE)
	1.25	CO	1	
	2.25	NO	1	STATIONARY INTERNAL COMBUSTION ENGINES (SPARK IGNITION)
	3.25	NO	1	BOILERS (10-250X10E6 BTU/HR)
	4.25	NO	1	EXPLOSIVES (HIGH)
	4.75	NO	1	BOILERS-MIXED FUEL (COAL AND REFUSE)
	5.25	NO	1	BOILERS-MIXED FUEL (OIL AND REFUSE)
	6.25	NO	1	STATIONARY INTERNAL COMBUSTION ENGINES (DIESEL AND DUAL FUEL)
	7.25	NO	1	CEMENT PLANTS (KILNS, CLINKER COOLERS)
	7.50	SO	1	
	8.50	NO	1	MUNICIPAL INCINERATORS
	9.50	NO	1	ADIPIC ACID
	10.50	NO	1	DMT/TPA (NITRIC ACID OXIDE)
	11.50	NO	1	FIBERGLASS (WOOL)
1976.0	1.50	NO	1	BOILERS (0.3-10X10E6 BTU/HR)
	2.50	NO	1	INDUSTRIAL/COMMERCIAL INCINERATORS
	3.50	NO	1	EXPLOSIVES (LOW)
	4.50	NO	1	AUTO BODY INCINERATORS
	5.50	HC	1	SURFACE COATING (INDUSTRIAL)
	6.50	HC	1	AMMONIA - METHANATOR PLANT
	7.50	HC	1	AMMONIA - REGENERATOR AND CO ABSORBER
	7.75	CO	1	
	8.75	HC	1	DEGREASING
	9.75	HC	1	ETHYLENE OXIDE
	10.75	HC	1	CARBON BLACK (FURNACE PROCESS)
	11.00	CO	1	
1976.5	1.00	HC	1	CHARCOAL
	1.25	PM	1	
	1.50	CO	1	
	2.50	HC	1	GRAPHIC ARTS (GRAVURE)
	3.50	HC	1	BEER PROCESSING
	4.50	HC	1	VEGETABLE OIL MANUFACTURING
	5.00	HC	1	DISTILLATE OIL STORAGE (BREATHING)
	5.50	HC	1	KEROSENE STORAGE (BREATHING)
	6.50	HC	1	SYNTHETIC RESIN (ACRYLIC)
	7.50	HC	1	FIBERS (NYLON)
	8.50	HC	1	WHISKEY PROCESSING
	9.50	HC	1	FIBERS (ACETATE)
	10.50	HC	1	TEXTILE PROCESSING (HEAT SETTING AND FINISHING)
	11.50	HC	1	TEXTILE PROCESSING (CARPET MANUFACTURING)

Table 4-15. (Cont'd.)

Year	Cumulative Effort	Pollutant	Standard Number[b]	Source
1977.0				
	1.50	HC	1	RUBBER (STYRENE - BUTADIENE)
	2.50	HC	1	LEAD ACID BATTERY ASSEMBLY PLANTS
	3.50	HC	1	SYNTHETIC RESIN (ALKYD)
	4.50	HC	1	TEXTILE PROCESSING (TEXTURIZING)
	5.50	HC	1	PETROLEUM REFINERY (MISC. POINT SOURCES)
	6.50	HC	1	REFUELING MOTOR VEHICLES
	7.50	HC	1	DRY CLEANING
	8.50	HC	1	SERVICE STATIONS
	8.70	HC	1	GASOLINE TRANSFER
	8.90	HC	1	CRUDE OIL TRANSFER
	9.10	HC	1	JET FUEL TRANSFER
	9.30	HC	1	AVIATION GAS TRANSFER
	9.50	HC	1	SPECIAL NAPHTHA TRANSFER
	10.50	HC	1	DIRECT FIRING OF MEATS
	11.50	HC	1	STATIONARY INTERNAL COMBUSTION ENGINES (DIESEL AND DUAL FUEL)
	11.75	CO	1	
1977.5				
	1.75	HC	1	PATHOLOGICAL INCINERATORS
	2.00	CO	1	
	3.00	HC	1	GRAPHIC ARTS (FLEXOGRAPHY)
	4.00	HC	1	PETROLEUM REFINERY (VACUUM DISTILLATION)
	5.00	HC	1	GRAPHIC ARTS (LETTER PRESS)
	6.00	HC	1	GRAPHIC ARTS (LITHOGRAPHY)
	7.00	HC	1	GRAPHIC ARTS (METAL DECORATING)
	8.00	HC	1	CAST IRON FOUNDRY (CORE OVENS)
	9.00	HC	1	PAINT
	10.00	HC	1	POLYETHYLENE (LOW DENSITY)
	11.00	HC	1	MALEIC ANHYDRIDE (BENZENE OXIDATION)
	11.25	CO	1	
1978.0				
	1.25	SO	1	PRIMARY COPPER SMELTERS
	2.25	SO	1	PRIMARY ZINC SMELTERS
	3.25	SO	1	PRIMARY LEAD SMELTERS
	4.25	SO	1	WOOD PULPING (NSSC)
	5.25	SO	1	WOOD PULPING (SULFITE)
	6.25	SO	1	WOOD PULPING (KRAFT PROCESS)
	7.25	SO	1	LIME PROCESSING
	8.25	SO	1	FIBERGLASS (TEXTILE)
	9.25	SO	1	FIBERGLASS (WOOL)
	10.25	SO	1	BOILERS-MIXED FUEL (COAL AND REFUSE)
	10.50	PM	1	
	11.50	SO	1	EXPLOSIVES (HIGH)
	11.75	PM	1	

Table 4-15. (Cont'd.)

Year	Cumulative Effort	Pollutant	Standard Number[b]	Source
1978.5				
	1.75	SO	1	SECONDARY LEAD SMELTER (REVERBERATORY FURNACE)
	2.75	SO	1	EXPLOSIVES (LOW)
	3.75	SO	1	SULFUR RECOVERY (REFINERY FUEL GAS)
	4.75	SO	1	SULFUR RECOVERY (CRUDE OIL AND NATURAL GAS PRODUCTION)
	5.75	HC	1	POLYETHYLENE (HIGH DENSITY)
	6.75	HC	1	VARNISH
	7.75	HC	1	PHTHALIC ANHYDRIDE (O-XYLENE)
	8.00	CO	1	
	9.00	HC	1	POLYVINYL CHLORIDE
	10.00	HC	1	PRINTING INK
	11.00	HC	1	PLYWOOD VENEER PROCESSING
1979.0				
	1.00	HC	1	DEEP FAT FRYING
	1.25	PM	1	
	2.25	HC	1	POLYSTYRENE
	3.25	HC	1	RESINS (PHENOLIC)
	4.25	HC	1	ASPHALT ROOFING (BLOWING)
	4.50	PM	1	
	4.75	CO	1	
	5.75	HC	1	MINERAL WOOL PROCESSING
	6.00	CO	1	
	7.00	HC	1	RESINS (UREA-MELAMINE)
	8.00	HC	1	FIBERGLASS (WOOL)
	8.25	CO	1	
	9.25	HC	1	RESINS (ABS-SAN)
	10.25	HC	1	POLYPROPYLENE
	11.25	HC	1	COFFEE ROASTING
	11.50	PM	1	
1979.5				
	1.50	PM	1	BOILERS (10-250X10E6 BTU/HR)
	3.50	PM	1	GRAIN MILLING AND STORAGE (PROCESSING)
	4.50	PM	1	STONE QUARRYING AND PROCESSING
	5.00	PM	1	GRAIN MILLING AND STORAGE (TRANSFER)
	6.00	HC	1	AUTO BODY INCINERATORS
	6.25	CO	1	
	7.25	HC	1	SECONDARY ZINC (SWEATING)
	7.50	CO	1	
	8.50	HC	1	MEAT SMOKEHOUSES
	8.75	PM	1	
	9.00	CO	1	
	10.00	HC	1	SECONDARY MAGNESIUM SMELTING
	10.25	CO	1	
	11.25	HC	1	ACRYLONITRILE
	11.50	CO	1	

Table 4-15. (Cont'd.)

Year	Cumulative Effort	Pollutant	Standard Number[b]	Source
1980.0				
	1.50	NO	2	BOILERS (>250X10E6 BTU/HR)
	2.50	NO	2	NITRIC ACID (AIR OXIDATION)
	3.50	PM	2	BOILERS (>250X10E6 BTU/HR)
	5.00	PM	1	INDUSTRIAL/COMMERCIAL INCINERATORS
	5.50	PM	1	GRAIN MILLING AND STORAGE (SCREENING AND CLEANING)
	6.50	PM	1	BOILERS-WOOD WASTE
	7.50	PM	1	BYPRODUCT COKE OVENS
	8.50	HC	1	FORMALDEHYDE
	8.75	CO	1	
	9.75	PM	1	LIME PROCESSING
	10.75	HC	1	ETHYLENE DICHLORIDE
	11.00	CO	1	
1980.5				
	1.00	PM	1	STEEL FOUNDRIES
	2.00	PM	1	CAST IRON FOUNDRY (ELECTRIC FURNACE)
	3.00	PM	1	PRIMARY COPPER SMELTERS
	4.00	PM	2	ASPHALT BATCHING
	5.00	PM	1	PLYWOOD VENEER PROCESSING
	6.00	CO	1	IRON AND STEEL PLANTS (BOF)
	7.00	PM	1	SAND AND GRAVEL
	8.00	PM	1	PRIMARY ALUMINUM SMELTERS
	9.00	PM	1	WHISKEY PROCESSING
	10.00	PM	1	VEGETABLE OIL MANUFACTURING
	11.00	PM	1	PHOSPHATE ROCK (GRINDING)
1981.0				
	1.00	PM	1	CONCRETE BATCHING
	2.00	PM	2	IRON AND STEEL PLANTS (ELECTRIC ARC FURNACE)
	3.00	PM	1	NITRATE FERTILIZER
	4.00	PM	1	COAL CLEANING (THERMAL DRYING)
	4.50	PM	1	GRAIN MILLING AND STORAGE (DRYING)
	5.50	PM	1	BEER PROCESSING
	6.50	PM	1	FEED MILLING AND STORAGE (OTHER)
	8.50	PM	1	FERROALLOY (ESA FURNACE)
	9.50	PM	1	SYNTHETIC RESINS (POLYESTER)
	10.50	PM	1	POLYPROPYLENE
	11.50	PM	1	SODIUM CARBONATE (NATURAL)

Table 4-15. (Cont'd.)

Year	Cumulative Effort	Pollutant	Standard Number^b	Source
1981.5	1.50	PM	1	COTTON GINNING
	2.50	PM	1	CERAMIC CLAY
	3.50	PM	1	FIBERS (DACRON)
	4.50	PM	2	PETROLEUM REFINERY (FCCU)
	5.50	PM	1	POLYVINYL CHLORIDE
	6.50	PM	2	SECONDARY LEAD SMELTER (REVERBERATORY FURNACE)
	7.50	PM	2	SECONDARY LEAD SMELTER (BLAST FURNACE)
	8.50	PM	1	BRICK AND RELATED CLAY PRODUCTS
	9.50	PM	1	AMMONIUM SULFATE FERTILIZER
	10.50	PM	1	IRON AND STEEL PLANTS (SINTERING)
	11.50	PM	1	PHOSPHATE ROCK (DRYING/HANDLING)
1982.0	1.50	PM	1	GYPSUM PROCESSING
	2.50	PM	1	DIAMMONIUM PHOSPHATE FERTILIZER
	3.50	PM	1	SUGAR CANE PROCESSING (BAGASSE BURNING)
	4.50	PM	1	ASPHALT ROOFING (SATURATOR)
	5.50	PM	1	IRON AND STEEL PLANTS (SCARFING AND ROLLING MILL COAL COMBUSTION)
	6.50	PM	1	STARCH MANUFACTURING
	7.50	PM	1	PAINT
	8.50	PM	1	SECONDARY ALUMINUM PRODUCTION (REVERBERATORY FURNACE)
	9.50	PM	1	SECONDARY COPPER (SMELTING AND REFINING)
	11.00	PM	1	SECONDARY COPPER (MATERIAL HANDLING)
1982.5	1.00	PM	1	FIBERS (NYLON)
	2.00	PM	1	FEED MILLING AND STORAGE (ALFALFA DEHYDRATING)
	3.00	PM	1	PETROLEUM REFINERY (PROCESS GAS COMBUSTION)
	4.00	PM	1	MINERAL WOOL PROCESSING
	5.00	PM	1	LEAD ACID BATTERY ASSEMBLY PLANTS
	6.00	PM	1	FLYASH SINTERING
	7.00	PM	1	FRIT PROCESSING
	8.00	PM	1	PHOSPHORIC ACID (THERMAL PROCESS)
	9.00	PM	1	PULPBOARD PROCESSING
	10.00	PM	1	PHOSPHATE ROCK (CALCINING)
	11.00	PM	1	PERLITE PROCESSING

Table 4-15. (Cont'd.)

Year	Cumulative Effort	Pollutant	Standard Number[b]	Source
1983.0				
	1.00	PM	1	AUTO BODY INCINERATORS
	2.00	PM	1	CARBON BLACK (FURNACE PROCESS)
	3.00	PM	1	DETERGENT (SPRAY DRIED)
	4.00	PM	1	GRANULATED TRIPLE SUPERPHOSPHATE FERTILIZER (STORAGE)
	5.00	PM	1	SECONDARY ALUMINUM PRODUCTION (SWEAT FURNACE)
	6.00	PM	1	CLAY SINTERING
	7.00	PM	1	MINING AND MILLING OF LEAD ORE
	8.00	PM	1	PRIMARY LEAD SMELTERS
	9.00	PM	1	PRIMARY ZINC SMELTERS
	10.00	PM	1	SECONDARY ZINC (SWEATING)
	11.00	PM	1	ANIMAL FEED DEFLUORINATION
1983.5				
	1.00	PM	1	RUBBER (STYRENE - BUTADIENE)
	2.00	PM	1	SECONDARY ZINC (DISTILLATION)
	3.00	PM	1	CASTABLE REFRACTORY
	4.00	PM	1	SOAP
	5.00	PM	1	SECONDARY LEAD SMELTER (POT FURNACE)
	6.00	PM	1	SECONDARY MAGNESIUM SMELTING
	7.00	PM	1	FISH PROCESSING (FISH MEAL COOKERS AND DRIERS)
	8.00	PM	1	DIRECT FIRING OF MEATS
	9.00	PM	1	PATHOLOGICAL INCINERATORS
	10.00	CO	1	WOOD PULPING (KRAFT PROCESS)
	11.00	CO	1	IRON AND STEEL PLANTS (ELECTRIC ARC FURNACE)
1984.0				
	1.00	CO	1	IRON AND STEEL PLANTS (BLAST FURNACE)
	2.00	CO	1	FERROALLOY (ESA FURNACE)
	3.00	CO	1	SECONDARY LEAD SMELTER (BLAST FURNACE)
1984.5				
1985.0				
	1.00	SO	2	BOILERS (>250X10E6 BTU/HR)
	2.00	SO	1	BOILERS (10-250X10E6 BTU/HR)
	3.00	NO	1	BOILERS (<0.3X10E6 BTU/HR)
	4.00	NO	1	GLASS (SODA-LIME)
	5.00	NO	1	PETROLEUM REFINERY (PROCESS GAS COMBUSTION)
	6.00	NO	1	FIBERGLASS (TEXTILE)
	6.25	CO	1	
	7.25	NO	1	LIME PROCESSING
	8.25	NO	1	BRICK AND RELATED CLAY PRODUCTS
	9.25	NO	1	CERAMIC CLAY
	10.25	NO	1	NITRATE FERTILIZER
	11.25	NO	1	BYPRODUCT COKE OVENS

Table 4-15. (Cont'd.)

Year	Cumulative Effort	Pollutant	Standard Number[b]	Source
1985.5				
	1.25	NO	1	PATHOLOGICAL INCINERATORS
	2.25	NO	1	GLASS (OPAL)
	3.25	NO	1	MINERAL WOOL PROCESSING
	4.25	NO	1	COFFEE ROASTING
	5.25	SO	1	BOILERS (0.3-10X10E6 BTU/HR)
	6.25	SO	1	BOILERS (<0.3X10E6 BTU/HR)
	6.75	SO	1	STATIONARY GAS TURBINES (ELECTRIC UTILITY)
	7.25	SO	1	STATIONARY GAS TURBINES (PIPE LINE)
	8.25	SO	1	COAL CLEANING (THERMAL DRYING)
	9.25	SO	1	STATIONARY INTERNAL COMBUSTION ENGINES (DIESEL AND DUAL FUEL)
	10.25	SO	1	BRICK AND RELATED CLAY PRODUCTS
	11.25	SO	1	ASPHALT BATCHING
1986.0				
	1.25	SO	1	BOILERS-MIXED FUEL (OIL AND REFUSE)
	1.50	PM	1	
	2.50	SO	2	SULFURIC ACID
	3.50	SO	1	SECONDARY LEAD SMELTER (BLAST FURNACE)
	4.50	HC	1	STATIONARY INTERNAL COMBUSTION ENGINES (SPARK IGNITION)
	4.75	CO	1	
	5.75	HC	1	BOILERS (>250X10E6 BTU/HR)
	6.00	CO	1	
	7.00	HC	1	BOILERS (0.3-10X10E6 BTU/HR)
	7.25	CO	1	
	8.25	HC	1	BOILERS (10-250X10E6 BTU/HR)
	8.50	CO	1	
	9.50	HC	1	BYPRODUCT COKE OVENS
	9.75	CO	1	
	10.75	HC	1	AUTOMOBILE ASSEMBLY PLANTS
	11.75	HC	1	INDUSTRIAL/COMMERCIAL INCINERATORS
	12.00	CO	1	

Table 4-15. (Cont'd.)

Year	Cumulative Effort	Pollutant	Standard Number[b]	Source
1986.5	2.00	HC	1	BOILERS (<0.3X10E6 BTU/HR)
	2.25	CO	1	
	3.25	HC	1	ASPHALT BATCHING
	4.25	HC	1	MUNICIPAL INCINERATORS
	4.50	CO	1	
	5.50	PM	1	BOILERS (0.3-10X10E6 BTU/HR)
	6.50	PM	1	BOILERS (<0.3X10E6 BTU/HR)
	7.00	PM	1	STATIONARY GAS TURBINES (ELECTRIC UTILITY)
	7.50	PM	1	STATIONARY GAS TURBINES (PIPE LINE)
	8.50	PM	1	STATIONARY INTERNAL COMBUSTION ENGINES (DIESEL AND DUAL FUEL)
	9.50	PM	1	GLASS (SODA-LIME)
	10.50	PM	2	CEMENT PLANTS (KILNS, CLINKER COOLERS)
	11.50	PM	2	MUNICIPAL INCINERATORS
1987.0	1.50	PM	1	FIBERGLASS (TEXTILE)
	2.50	PM	1	GLASS (OPAL)
	3.50	PM	2	BRASS AND BRONZE SMELTING
	4.50	CO	1	IRON AND STEEL PLANTS (SINTERING)
1987.5				
1988.0				
1988.5				
1989.0				
1989.5				

[a] Strategy 9, Table 4-13.

[b] Existing standards assumed to be in effect in 1975. Standard No. 0 implies a state standard for new sources, No. 1 implies the first federal NSPS, No. 2 implies a revised federal NSPS.

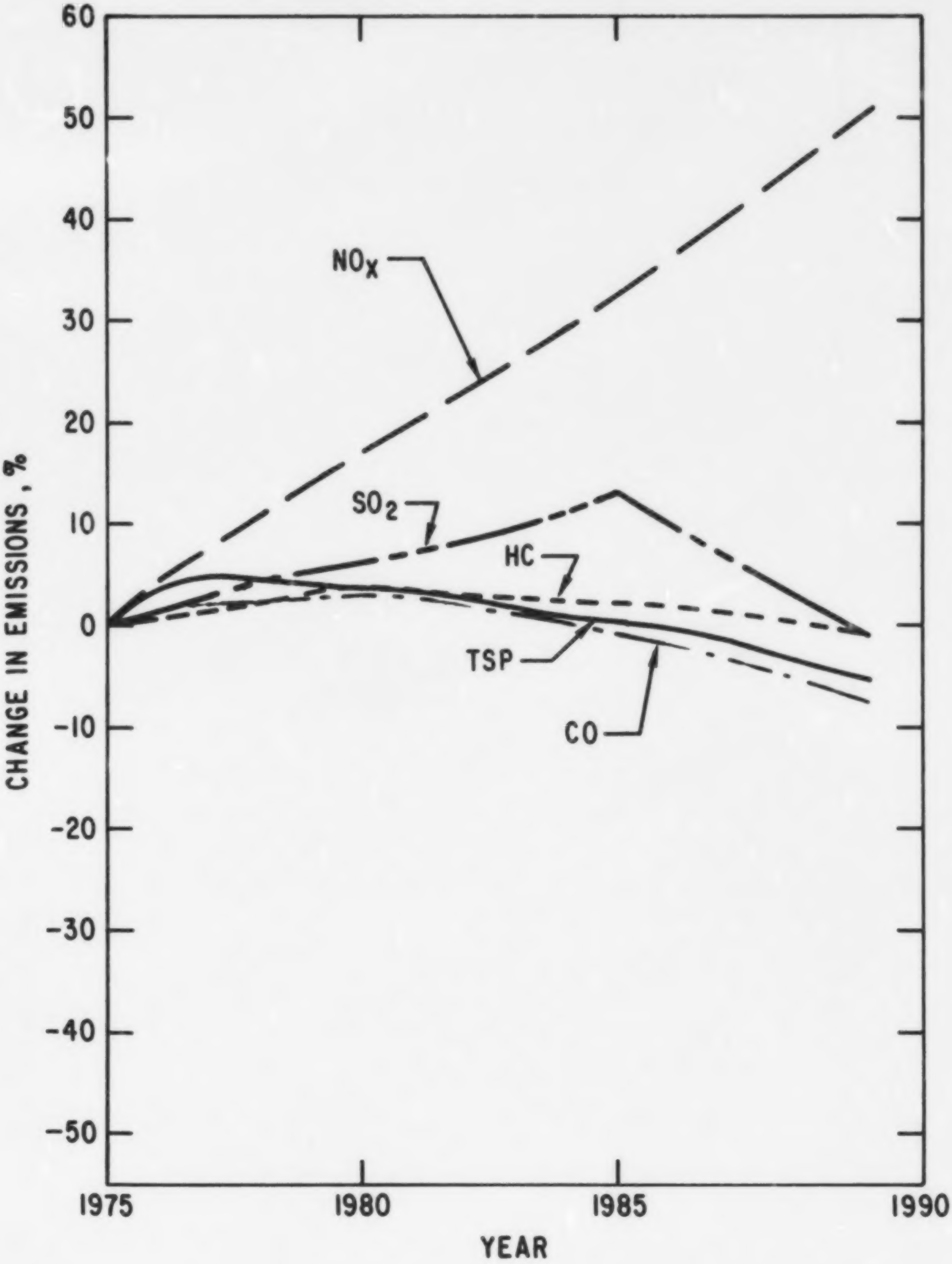

Fig. 4-13. Combined Pollutant Emission Projections for Stationary Sources with NO_x Emphasis (Strategy 9).

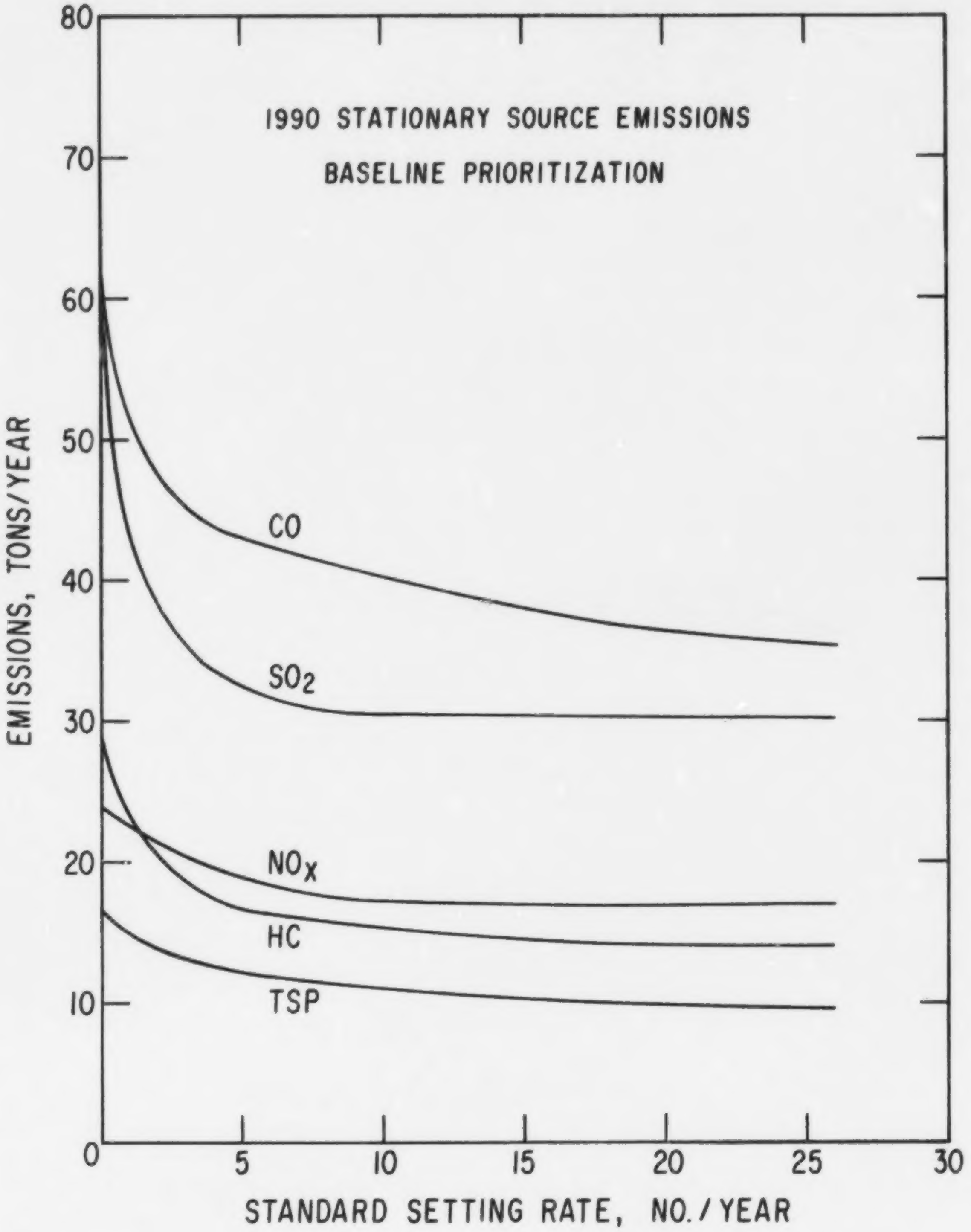

Fig. 4-14. Emission Projections as a Function of Standard-Setting Rate

Strategy 14 is a simulation of the effect of parallel versus serial standard development as discussed in Section 6.2. This strategy shows that developing a larger group of standards simultaneously with the same resources, assuming that the time between groups of standards is larger although the average number of standards per year is constant, results in a small but measurable increase in projected emissions.

Since only sources that initiate construction or modification after the standard promulgation date are regulated by the standard, there may be a time lag of up to 4 or 5 years before these new regulated sources are in operation and the emission control is effective. This important consideration was approximated in Strategy 15 by assuming that the effect of any new standard from the baseline Strategy 4 would not be in effect for 2-1/2 years. (This is equivalent computationally to not allowing standards to be "set" for 2-1/2 years after 1975. The date a standard is "set" is then the time when the standard's effect is noticed when in actuality it was promulgated 2-1/2 years earlier. The effect of existing standards was approximated to begin in 1975.) The emissions from this simulation shown in Fig. 4-15 are significantly larger than when the effect is ignored and is probably a more realistic estimate of the actual emissions than is Strategy 4. The addition to this simulation of transportation emission projections from Appendix A is shown in Fig. 4-16. The total NO_x emissions relative to 1975 are less than for point sources alone, but still more than a 16% increase by 1990. The relative total emissions for HC and CO are considerably less than for point sources alone, but there is little difference in TSP and SO_2 projections resulting from the addition of the transportation emissions.

Strategy 16 simulates the impact of setting standards for all pollutants emitted by a source category at the same time. In effect, when a source is scheduled to have a standard set for its priority pollutant, the constraints on all other pollutants are relaxed so that all may be set simultaneously. (The exception is the fuel switching and research and development constraints which are still maintained until 1985.) The advantage to this procedure is that economies of effort may be achieved through the use of common data for all pollutant standards. In part (a) of the strategy it is assumed that each additional standard requires 25% more effort than the initial priority standard. In part (b) it is assumed that 75% more effort is required for

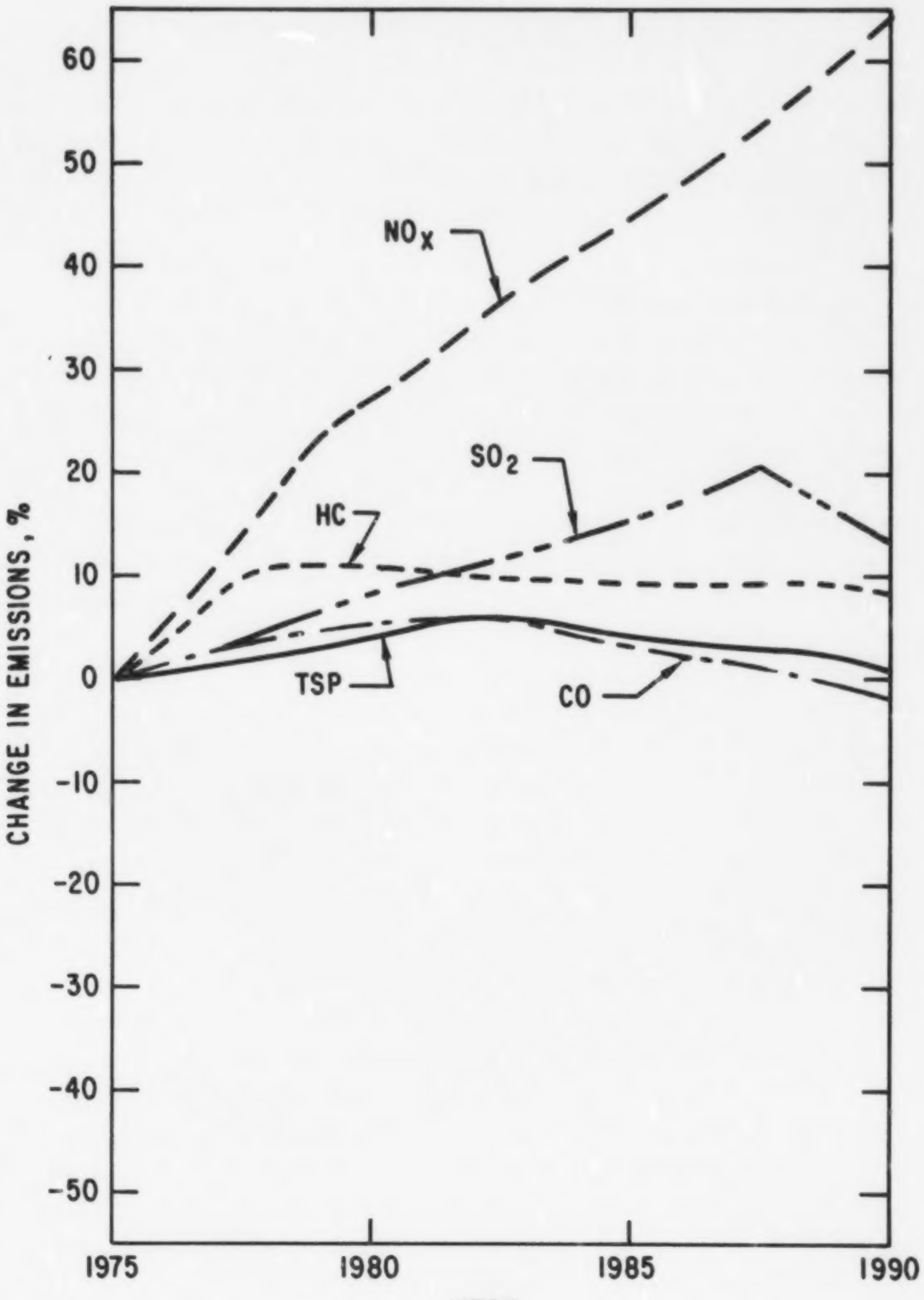

Fig. 4-15. Combined Pollutant Emission Projections for Stationary Sources with Delay in NSPS Impact (Strategy 15).

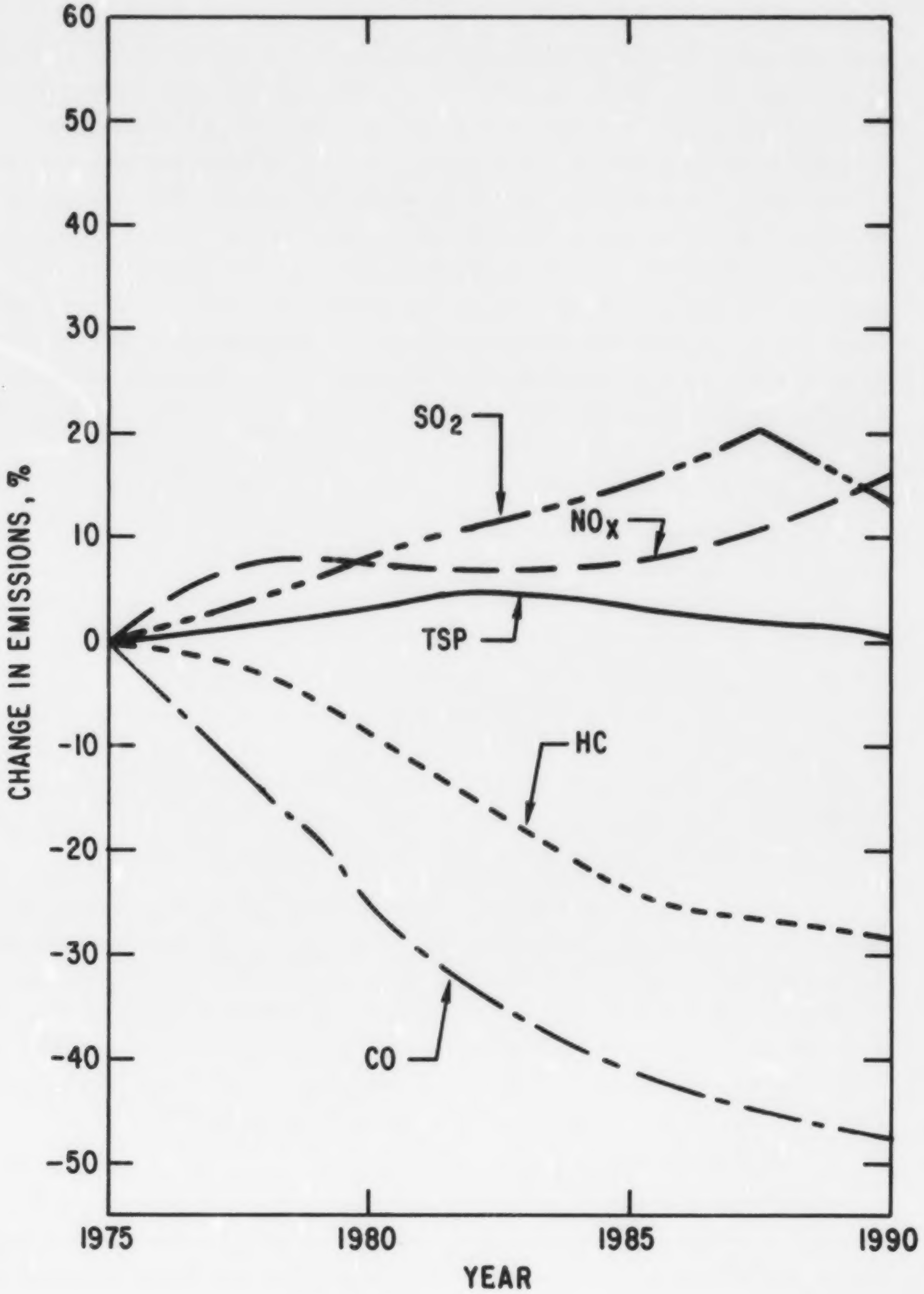

Fig. 4-16. Combined Pollutant Emission Projections for Stationary and Mobile Sources with Delay in NSPS Impact (Strategy 15).

each additional standard. Comparing these results to the baseline (Strategy 4) show very little change in hydrocarbons, NO_x, and SO_2 with improvements in the emission pattern for particulates and CO. This is true because the priority emphasis placed on hydrocarbons, NO_x, and SO_2 has not been altered by very much. Standards for particulates and CO, however, are accelerated by being tied to the higher priority pollutants. Assuming a .75 effort increment instead of a .25 increment (i.e. Strategy 16b. compared to 16a.) produces only small perturbations in the emission pattern. It is evident, therefore, that this strategy could be used to effect standard development cost savings with a minimal impact on emissions. This procedure would apply to about 62 industry categories.

4.8 SPECIAL PRIORITY AREAS

The combined pollutant priority ranking just described relied on the use of objective emission reduction criteria to determine the pollutant that should receive priority consideration. The special priority areas of emphasis of Section 3.3 outline other considerations that can alter the ranking. By making these alterations, it is evident that gains in emission control for the priority pollutants or industries will be made at the expense of others. The question of determining the magnitude of the penalties can be answered with the emission projection model. The more crucial question of whether the penalties are acceptable in light of the priority needs can only be answered by an evaluation of national environmental control objectives.

Using some of the information previously discussed as well as some additional computations, Table 4-16 summarizes the emission control benefits and penalties associated with the special priority areas of emphasis identified in Section 3.3. The baseline case against which these are measured is a criteria of no emission increase over 1975 levels for all criteria pollutants except NO_x. For NO_x, the maximum achievable reduction of 44.4% is set as the criteria. This baseline, then, is identical to Strategy 4 in Section 4.7.

For the pollutant priorities of Section 3.3.1, it is possible to discriminate between priority pollutants and nonpriority pollutants. For the strategy priorities of Section 3.3.2, this is not always possible. In such cases, all pollutants are considered nonpriority and the impact is determined. In all instances, the measure of benefit and penalty is the change in the

Table 4-16. Impact of Special Priorities on Stationary Source Emissions

	All Changes Measured Relative to the Baseline Strategy[a]					
	Priority Pollutants			Nonpriority Pollutants		
Priority Area of Emphasis		Change in Max. Emission Rate (10^3 tpy)	Change in 1990 Efficiency Ratio (%)		Change in Max. Emission Rate (10^3 tpy)	Change in 1990 Efficiency Ratio (%)
1. Nitrogen Oxide Control[b]	NO_x	-120	+1.7	TSP	+100	-3.2
				SO_2	+335	-1.7
				HC	+233	-1.1
				CO	+243	-2.2
2. Hydrocarbon Control[c]	HC	- 75	+1.3	TSP	+108	-3.3
				SO_2	+710	-2.7
				NO_x	+582	-8.4
				CO	+125	-2.4
3. Particulate Control[d] for	TSP	-262	+7.7	SO_2	+571	-2.2
NAAQS Attainment				NO_x	+424	-6.1
Air Quality Maintenance				HC	+452	-3.0
Fine Particulate Control				CO	+636	-4.1
4. Sulfur Oxide Control[e] for	SO_2	-385	+1.5	TSP	+107	-3.3
NAAQS Attainment				NO_x	+317	-4.6
Air Quality Maintenance				HC	+307	-1.8
Sulfate Control				CO	+434	-3.1
5. Nondegradation Source Control	TSP	-130	+0.7	NO_x	+525	-7.6
	SO_2	-225	+0.9	HC	+541	-3.5
				CO	+592	-2.5
6. Emerging Industry Control				TSP	+ 14	-0.4
				SO_2	+ 67	-0.3
				NO_x	+ 2	0
				HC	+ 24	-0.1
				CO	+ 78	-0.9
7. Energy Conservation						
a. Accelerate conservation standards				TSP	+ 9	-0.3
				SO_2	+ 44	-0.2
				NO_x	+ 60	-0.9
				HC	+ 4	-0.1
				CO	-838	+6.9
b. Accelerate Conservation standards and prohibit fuel-consumption-increasing standards				TSP	- 10	-0.3
				SO_2	-214	-1.5
				NO_x	+ 97	-1.4
				HC	- 9	-1.0
				CO	-838	+3.4
8. Noncriteria Pollutant Control[f]	Data limited on noncriteria pollutant emissions			TSP	+ 85	-6.0
				SO_2	+103	-0.4
				NO_x	+ 17	-0.3
				HC	+106	-1.2
				CO	+265	-5.8

[a] Baseline is chosen as Strategy 4, Table 4-13.

[b] Strategy 9, Table 4-13.

[c] Strategy 6, Table 4-13.

[d] Strategy 5, Table 4-13.

[e] Strategy 7, Table 4-13.

[f] Strategy 12c, Table 4-13.

maximum emission rate and in the 1990 efficiency ratio relative to the baseline strategy.

4.8.1 Nitrogen Oxide and Hydrocarbon Emphasis

These pollutants were identified in Section 3.3.1 as having priority consideration. The baseline strategy discussed in Section 4.7 reinforces this conclusion. By imposing a zero emission increase criterion, both pollutants are ranked near the top of the priority list as a result of their high growth rates without NSPS controls. The first two cases on Table 4-16 show the impact of further emphasizing each pollutant by imposing tighter emission reduction criteria on these compared to the other pollutants (see Strategies 9 and 6 on Table 4-13).

For NO_x, a reduction in the maximum emission rate of 120 thousand tons/year over the baseline case is possible with a corresponding penalty of emission increases for the other pollutants. Most seriously affected are SO_2, CO, and hydrocarbons, which will experience increases of 335, 243, and 233 thousand tons/year, respectively, in the maximum emission rate relative to the baseline. Particulate emission control will suffer the most in 1990 with a 3.2% reduction in efficiency ratio relative to the baseline. A judgment as to whether the reduction in nitrogen oxides is sufficiently warranted to justify these penalties must be made prior to adopting this strategy.

Emphasis on hydrocarbon control could reduce the maximum emission rate by 75 thousand tons/year, but only with a severe penalty to NO_x control; the maximum emission rate of nitrogen oxides is increased by more than half a million tons/year. SO_2 emissions increase by more than 700,000 tons/year. This result is primarily due to the fact that large increments in the control of HC emissions are achieved only through the control of many moderately-sized industries rather than a few large ones. The development of many standards takes more time and results in substantial delays in the development of NO_x and SO_2 standards. This is evidently a poor change in priorities if NO_x control and HC control are to be considered of equivalent importance.

4.8.2 Particulate and Sulfur Oxide Control

The emphasis for control of particulates and sulfur oxides was identified in Section 3.3 as the result of the need to augment NAAQS attainment programs and the air quality maintenance planning program. Particulate control can also be viewed as stemming from the need to control fine particulates under the assumption that the setting of a particulate NSPS could be geared to controlling particle sizes also. Likewise, SO_2 standards can be tied to the need for sulfate control.

Using a more stringent emission reduction criteria for particulates and SO_2 (see Strategies 5 and 7, Table 4-13), a reduction of 262 and 385 thousand tons/year, respectively, in the maximum emission rate could be realized. The penalties would be more than 400 thousand tons/year for NO_x and HC with particulate emphasis and over 300 thousand tons/year for NO_x and HC for SO_2 emphasis. The NO_x penalty is not as great as for the increased emphasis on HC, since substantial emission reductions are achieved through control of a few large particulate and SO_2 sources with shorter time delays in the starting of work on NO_x standards. Nevertheless, the impact on NO_x and HC control is significant and must be weighed in the light of requirements for control of these pollutants.

4.8.3 Nondegradation Source Control

Table 4-17 lists those sources currently identified for control under proposed nonsignificant deterioration regulations;[8] the emphasis is on particulate and SO_2 emission reduction. Some of the sources have NSPS set already, hence the emphasis for NSPS development in support of nondegradation regulations would be on setting standards for the other sources and perhaps revising existing standards. To determine the maximum impact of accelerating the development of these standards, it was assumed that all new or revised NSPS for these sources would be set prior to all other standards. Fuel switching and research constraints were maintained, however. Using the nominal standard-setting pace of 22 per year, the necessary new and revised standards could all be set by the end of 1976.

It is evident from the data on Table 4-16 that accelerating the promulgation of standards for these industries will incur an emission penalty for all non-priority pollutants. Particulate and SO_2 emissions experience only relatively small decreases in the maximum emission rate.

Table 4-17. Source Categories Considered for Nondegradation Controls of TSP and SO_2

Source	Pollutant
Boilers (>250x10^6 Btu/hr)[a]	TSP, SO_2[b]
Coal Cleaning Plants	TSP,[c] SO_2[b]
Kraft Pulp Mills	SO_2
Portland Cement Plants[d]	TSP,[e] SO_2
Kilns, Clinker Coolers	
Concrete Batching	
Primary Zinc Smelters	TSP, SO_2
Iron and Steel Mills	
Basic Oxygen Furnace	TSP[f]
Electric Arc Furnace	TSP[g]
Sintering	TSP
Scarfing and Rolling Mill	TSP
Primary Aluminum Ore Reduction	TSP
Primary Copper Smelters	TSP, SO_2[c]
Municipal Incinerators[h]	TSP
Sulfuric Acid	SO_2[e,g]
Petroleum Refineries	
Fluidized Catalytic Cracker Unit	TSP
Process Gas Combustion	TSP,[g] SO_2[f]
Lime Plants	TSP, SO_2
Phosphate Rock Processing	
Grinding	TSP
Drying	TSP
Calcining	TSP
By-Product Coke Oven	TSP
Sulfur Recovery	
Refineries	SO_2
Oil and Natural Gas Production	SO_2
Carbon Black (Furnace Process)	TSP
Primary Lead Smelters	SO_2[c], TSP[c]
Fuel Conversion Plants	i

[a] The proposed regulations cover only boilers > 1000 x 10^6 Btu/hr. This disaggregation is not available from the Model IV data so all the large boilers are included and considered for revised NSPS.

[b] Subject to fuel switching constraint (FS).

[c] Standard recently promulgated.

[d] It is assumed that regulations must be adopted for all operations in the plants.

[e] Subject to research required constraint (RD).

[f] Existing standard.

[g] Revised NSPS.

[h] The proposed nondegradation regulations cover only incinerators > 250 tons/hr.

[i] Data not available.

4.8.4 *Emerging Industry Control*

Table 4-18 lists the emerging industries considered for special NSPS priority. Since only a few standards are involved, the impact on the overall NSPS schedule is minimal. Table 4-16 shows that the maximum impact, resulting from setting all these standards before any others, changes the 1990 efficiency ratio by less than 1% for all pollutants. The indications are, therefore, that the allocation of some resources to the development of emerging industry NSPS can be tolerated without serious disruptions to the total emission control program.

4.8.5 *Energy Conservation*

The restructuring of the NSPS prioritization to accommodate energy considerations can take two forms. The first is to accelerate the promulgation of standards that result in energy conservation through their implementation. Included in this group are sources with Factor 7 on the standard industrial evaluation form (Fig. 3-1) rated as 0. These sources consist primarily of evaporative loss sources (e.g., petroleum storage and handling) and sources that are controlled through the use of an afterburner that requires no additional fuel input and from which heat recovery is possible. The second form of energy conservation consideration is to delay standards for all sources that would incur energy penalties (i.e., Factor 7 rated as 2 or 3). Specific source categories falling into these two groups can be identified from Tables 4-2, 4-4, 4-6, 4-8, and 4-10.

Table 4-16, Case 7, gives the impact of energy conservation consideration on stationary source emissions. In part (a), standards for the energy conservation sources are promulgated prior to starting any work on other categories. A total of 25 standards are involved. The change in emissions over the baseline case is relatively small since most of the standards set are for hydrocarbons and NO_x, which are emphasized in the baseline strategy anyway. The CO emissions drop significantly due to the early standard-setting for the carbon black, ammonia (regenerator and CO absorber), and charcoal source categories.

In part (b), the standards for those sources that would require moderate or heavy increases in energy consumption are delayed to some time later than 1990. As before, the emission impact is small. The clear indication

Table 4-18. Source Categories Considered for Emerging Industry Priorities

Source	Pollutant
Stationary Gas Turbines	TSP,[a] SO_2[a], NO_x, CO
Pipeline	
Electric Utility	
Sulfur Recovery Plants	
Refineries	SO_2
Oil and Natural Gas Production	SO_2
Sewage Sludge Incinerators	TSP[b]
Mixed Fuel Boilers	
Oil and Refuse	TSP[c], SO_2,[c] NO_x
Coal and Refuse	TSP, SO_2, NO_x

[a] Subject to fuel switching constraint.

[b] Standard already set.

[c] Subject to research required constraint (RD).

here is that the reordering of NSPS priorities to minimize increases in energy utilization can be achieved with only minor emission penalties.

4.8.6 Noncriteria Pollutant Control

Case 8 on Table 4-16 shows the effect of allocating some resources to the development of NSPS for noncriteria pollutants. In this instance, the number of criteria pollutant standards is decreased from 22 per year to 18 per year. Only a limited amount of data was available to assess the possible benefits in noncriteria pollutant emission reductions; however, the increases in criteria pollutant emissions are nominal. There appears, therefore, to be some margin for diversion of resources without the need to create intolerable emission increases.

5. EMISSION CONTROL TECHNOLOGY: LIKELY NEAR-TERM PROGRESS

The timetable for setting New Source Performance Standards (NSPS) has already been shown to depend on new developments in the capabilities of control systems. Ongoing research and development programs in EPA's Industrial Environmental Research Laboratory and elsewhere are designed to advance the technology of measurement and control, thereby permitting both the development of performance standards for source categories not previously covered and the modification of existing standards. Consequently, an informed prioritization scheme for setting NSPS should attempt to anticipate technological developments and to provide for timely incorporation of improvements in demonstrated technology as they become available. In addition, the analysis of priorities for setting NSPS can be used to identify deficiencies in the research programs, as critical needs for improved control technology are uncovered. The aims of this section are to describe the ongoing research programs in air pollution control technology and to indicate expected technological developments on the near horizon.

Descriptions of research programs on control systems can be found in many sources, including journal articles, laboratory reports, and company publications. Only technological developments carried through demonstration testing in industrial plants are included in this review. Unfortunately, many reports of research programs on control systems give no indication of when commercially proven technology will be available. Most of the information on which the development schedules given below are based was obtained from achievement plans for research programs of the EPA/IERL, ERDA, EPRI, and from other publications in the open literature.

5.1 EXPECTED DEVELOPMENTS IN EMISSION CONTROL TECHNOLOGY

5.1.1 *Sulfur Oxides Emission Control Systems*

Sulfur, emitted to the atmosphere as sulfur oxides, results largely from the combustion of sulfur-bearing fuels, with coal combustion accounting for about 60% of the total. At the present state of the art, three methods are available that can effectively reduce sulfur oxide emissions: 1) switching to a low sulfur fuel, 2) desulfurizing the fuel, and 3) desulfurizing the flue gases produced.

Based on a recent survey of control technologies for sulfur emissions,[22] flue gas desulfurization (FGD) appears to be the only viable alternative (through 1980), other than the burning of scarce, clean fuels that can meet the current regulatory specifications. Desulfurization techniques for the production of clean fuels are not expected to make a substantial contribution until after 1980. Therefore, in considering the near-term needs of the country, the continuing development and implementation of FGD technology is of considerable importance.

The major division in the present FGD technologies is between regenerable processes and non-regenerable processes, as summarized in Table 5-1. Since the descriptions of each of these processes are presented in a great number of publications, they are not discussed in detail here. Descriptions of these processes and information on their performance, reliability, operating experience, relative advantages and disadvantages, and their SO_2 removal efficiencies can be found in a number of status reports.[23-25] In addition, proceedings[26] devoted entirely to this subject are available for general reference.

Some of these processes have been operating successfully in a number of commercial plants. The installations include steam boilers, oil refinery Claus sulfur plants, sulfuric acid plants, copper smelters, and iron-ore sintering. The units range in size from 5 Mw or less to as large as 250 Mw.* Present progress in this area is advancing toward design and construction of units 300 Mw and larger. All of these FGD processes are expected to find widespread commercial use within the next few years.

In addition, many other FGD processes that were not as well known before the Atlanta symposium[26] are gaining recognition. These are the Foster-Wheeler Bergbau Forschung process,[27] the Citrate process,[28] the Consol Stack Gas process,[29] and others.[25,30] Since most of these processes are still in early stages of development, significant contributions are not expected before 1980.

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*All plant sizes are expressed in megawatts (Mw), on the assumption that 1900SCFM of wet stack gas corresponds to 1 Mw.

Table 5-1. Summary of Methods Currently Available for SO_2 Removal from Stack Gases

System	Method	Byproducts	Process Description
Regenerable	1. Wet-alkaline adsorption and thermal regeneration	Concentrated SO_2 gas stream	The process involves wet scrubbing of stack gases with an aqueous alkaline solution or a magnesium oxide slurry to capture SO_2 as sulfite or bisulfite. This is followed by thermal regeneration of the sulfite or bisulfite to yield a concentrated SO_2 stream. The resultant gas can be transported to a contact sulfuric acid plant producing 98% acid. In the MgO process the resultant sulfite is calcined to yield SO_2, and a recovered slurry containing mostly MgO is recycled.
	2. Dry adsorption	Concentrated SO_2 gas stream	The SO_2 in the stack gas is adsorbed on either a metal oxide (such as CuO) or activated carbon. In the regeneration step the captured SO_2 may either be oxidized to yield sulfuric acid or be reduced to elemental sulfur. Some manufacturers prefer the oxidation step, so that the acid produced can react with lime to form gypsum (a saleable product).
	3. Catalytic oxidation	SO_3 or sulfuric acid	In the presence of a catalyst SO_2 gas is converted to SO_3 at high temperature. In this case the SO_3 reacts with moisture in the stack gas to form H_2SO_4 mist that is scrubbed out in the packed tower by a dilute recirculated acid stream to yield 80% acid.

Table 5-1. (Contd.)

System	Method	Byproducts	Process Description
Non-regenerable	1. Lime/limestone scrubbing	$CaSO_3/CaSO_4$ sludge or $CaSO_4$ solid	This is the oldest and most used technology for SO_2 removal. The SO_2 gas is scrubbed with lime or a limestone slurry to form a wet sludge, which is a throw-away product. Most Japanese installations of this process include an oxidation step, so that the end-product is dry gypsum (a saleable product).
	2. Double alkaline scrubbing	$CaSO_3/CaSO_4$ sludge	The process involves the operation of two closely related loops. The first is an adsorption and reaction step in which SO_x from the stack gas is captured in an aqueous alkaline solution containing NaOH or NH_4OH. The second is a regeneration step. The resulting sulfite/sulfate solution is then reacted with lime or limestone to form $CaSO_3/CaSO_4$ sludge. The regenerated alkaline solution is recycled to the scrubber. Again, Japanese versions of this process include an oxidation step to produce dry gypsum for sale. Efforts in the U.S. are now underway to deal with the sludge disposal problem.

Table 5-2 lists the seven basic processes used by suppliers in designing commercial units now in successful operation. Among them, the approach using lime/limestone scrubbing appears to be the most economical and acceptable process for SO_2 emissions control. Based on current trends, technology availability, qualified system suppliers, and lead-time considerations, it appears that the majority of FGD commercial installations through 1980 will be of the lime/limestone wet scrubber type.

Table 5-2. Types of Processes Available for Removal of Sulfur Dioxide from Stack Gases.

1. Sodium sulfite scrubbing with thermal regeneration.
2. Lime slurry scrubbing.
3. Dual media system employing dilute sulfuric acid for scrubbing.
4. Dual alkali systems.
5. Copper oxide acceptor (dry adsorption).
6. Activated carbon (dry adsorption).
7. Catalytic oxidation.

One of the major problems inherent in the lime/limestone system is the necessity to dispose of or utilize large quantities of a sulfur-containing byproduct. With current efforts concentrating on throwaway processes, the disposal of these sludges adds to the existing cost of fly-ash disposal in coal-fired utility power plants.

Recent studies of FGD systems have emphasized processes in which the SO_2 is recovered as a product of marketable value, such as gypsum or sulfuric acid. Most of the processes in this category are used in Japan and many have been demonstrated quite successfully with respect to system reliability and SO_2 removal efficiency. With the installation of recent demonstration plants, it is now possible to run economic evaluations of these processes that examine the tradeoff between process cost and byproduct income or waste-disposal cost. The ultimate choice among these alternatives will become clearer as operating experience with the newer processes accumulates.

In addition to FGD processes, front-end or integral processes for desulfurization of fossil fuels offer an additional prospect for SO_2 control. The objective of these processes is to convert high sulfur coal into low sulfur coal, premium liquid fuels, or pipeline-quality synthetic natural gas of low sulfur content. Processes currently being investigated are: 1) physical coal cleaning, 2) chemical coal cleaning, 3) solvent coal refining, 4) fluidized-bed combustion, 5) coal gasification (both high- and low-heating value gas), and 6) coal liquefaction. Since most of these are either at the pilot-plant stage of development or are economically uncertain, it is unlikely that any can have a significant impact on the total national sulfur emissions before 1985.

Recently, other new concepts in flue gas cleaning have begun to emerge. These are systems that can remove simultaneously two or more pollutants. Processes belonging to this category are discussed in Section 5.1.4.

5.1.2 Nitrogen Oxides Emission Control Systems

Current investigations of NO_x control technology can be divided into two different approaches:

1. The more near-term approach involves combustion modifications such as reduction of the peak gas temperature, reduction of the air/fuel ratio, and alteration of the time-temperature history of the combustion gases; the use of alternative fuels with lower nitrogen content; and flue gas cleaning.
2. More distant solutions include pressurized fludized-bed combustion of coal, fluidized-bed gasification/desulfurization of residual fuel oil, advanced power cycles, and other novel devices such as catalytic combustors.

Based on recent reports by Brown et al.[31] and Lachapelle et al.,[32] it appears that the most attractive near- and long-term options for the control of NO_x emissions will be through combustion modifications. Bench-scale studies and field tests indicate that the projected near-term goals (through 1980) for NO_x control of all utility and industrial boilers (burning gas, oil, or coal) can generally be attained with present burner/furnace modifications.

Table 5-3 summarizes the methods currently being evaluated for NO_x control achieved through combustion modifications. Plans incorporating applications of these methods, covering all types and sizes of furnaces and many different fuels, are now underway. The results of these studies will provide a basis for the evaluation of combustion control technology for major sources of NO_x emissions.

Table 5-3. Summary of Methods Currently Available for NO_x Control through Combustion Modifications

Technique	Method	Major Application	NO_x Control Effectiveness	Major Effects	Difficulties
1. Operating condition modifications	Low excess air combustion	Gas and oil combustion	20-30%	Peak temperature reduction	Increases emission of unburned fuels, carbon monoxide, and smoke; boiler vibration, slagging, and fireside corrosion
	Two-stage combustion	Gas and oil combustion	40-50%	Peak temperature reduction	Efficiency reduction; slagging and fireside corrosion
	Flue gas recirculation (FGR)	Tangentially-fired gas burners	30-35%	Peak temperature reduction	Retrofit difficulties; inability to meet load demand; additional controls required; efficiency reduction
	Reduced air preheat	Tangentially-fired gas burners	20%	Peak temperature reduction	Thermal efficiency reduction
	Steam or water injection	Gas and distillate oil-fired systems	10%	Peak temperature reduction	Fuel penalty
2. Design modifications	Burner configuration, location and spacing	All burners	Not available	Allow effective gas recirculation to combustion zone	Applicable only to new plants: no retrofit
	Tangential firing	All burners	50-60%	Peak temperature reduction	Slagging and corrosion; design problems
	Air and fuel flow pattern	All burners	Not available	Off-stoichiometric firing	High CO concentration in stack gas
	Fluidized-bed combustion (see Section 5.1.4)	Coal combustion	Not available	Better heat transfer ability	Low combustion efficiency; poor gas distribution; agglomerate formation; high NO_x formation with coals with large amounts of fuel-bound nitrogen.

The methods mentioned in Table 5-3 are noteworthy as they can be effectively utilized in combination to achieve very low rates of NO_x emission. For example, tests[33] on a 320-Mw corner-fired unit using off-stoichiometric combustion have shown that nitrogen oxide emissions are reduced from 330 to 110 ppm; and when combined with 30-35% flue gas circulation, the remaining emissions are further reduced by 50%. Note, however, that the reductions obtained by using individual techniques cannot be added when using systems in combination. The combined-system effectiveness of NO_x control must be measured for each integrated system.

Perhaps the most difficult factor in developing effective NO_x control through furnace modifications is the removal of the NO_x obtained from the fuel-bound nitrogen as opposed to that derived from nitrogen in the combustion air.[34] The NO_x formed from fuel-bound nitrogen is produced at much lower flame temperatures than that for conversion of atmospheric nitrogen.[35] Therefore, it remains to be determined whether combustion modifications alone can adequately control the NO_x from fuel nitrogen. The answer to this question may be found when a detailed understanding of the reaction mechanisms for formation of NO_x in the combustion process becomes available. It should then be possible to construct viable theories for the control of NO_x.

An alternative to burner modifications is flue gas treatment to remove nitrogen oxides that are produced during combustion. Flue gas treatment appears to be especially promising for cases where either the NO_x concentration is high or a very low level of NO_x emission is required. Three basic approaches[33,36] to flue gas cleaning for control of NO_x emissions are under development:

1. Catalytic processes including decomposition of NO_x to nitrogen and oxygen, selective reduction of NO_x by NH_3, and simultaneous removal of SO_x and NO_x from flue gas.

2. Physical separation processes involving adsorption of NO_x by solids such as activated carbon or molecular sieves.

3. Chemical separation processes involving absorption of NO_x by liquids such as aqueous acid or alkaline scrubbing solutions.

Preliminary studies show that none of these processes is adequate, by itself, for NO_x control. To date there is no commercially available flue gas treatment process for reducing the concentration of NO_x in power plant emissions. The known adsorbents and absorbents have low capacity, and known catalytic decomposition and reduction methods cannot handle large volumes of dilute stack gas. The indication is that flue gas treatment will be useful only as a secondary cleanup step.

5.1.3 Particulate Emission Control Systems

The emphasis of the research programs on control of particulate emissions has shifted in the last two years to development of systems for removal of fine particulate matter (particles of diameter 0.01-3 microns). This shift has occurred in response to the increasingly impressive amount of evidence that particulates in this size range are a major health hazard because of deep penetration into the lungs and long retention times that result from their inhalation. In addition, there is a growing concern about the health effects of trace metals in fine particulates. Evidence is accumulating that many potentially hazardous trace elements including arsenic, selenium, cadmium, and lead are concentrated in the fine particulate emissions from coal combustion sources.[37] Although the control of emissions of large particles is fairly well handled by conventional devices (see Table 5-4), the collection efficiency of these devices drops appreciably with decreasing size for submicron particles.

The current research program on control technology for fine particulates includes efforts to increase both the capability of conventional equipment for the collection of fine particulates and a number of developmental programs for novel devices. Both approaches are proving effective, and significant improvements in the efficiency of control of fine particulate emissions can be expected in the next few years. A summary of the current research efforts in this area and the anticipated dates of completion of demonstration studies for the various control devices under investigation follows:

1. Field tests of conventional particulate devices using specially designed mobile units are planned to continue through 1980. The purpose of these studies is to assess the capability and limitations of fabric filters, scrubbers, cyclones, and electrostatic precipitators for reducing particulate emissions from different kinds of sources in

Table 5-4. Summary of Commercial Methods for Particulate Removal from Stationary Sources

Method	Efficiency (%) for Different Particle Diameters[a]			Typical Applications[b]
	Overall	>1 micron	<1 micron	
1. Electrostatic precipitator (ESP)	98-99+	96-99+	80-99	Wide variety of solid and liquid particles
2. Scrubber	Not available	70-99+	7-90[d]	In addition to general use, the system is capable of providing limited control for odor, acid mists, and soluble components in flue gas
3. Fabric filter[c]	99+	∿98-99+	94-99+	Special features of this method include collection of corrosive particulates with effective operation at moderate to high temperatures
4. Dry centrifugal collector (cyclone)	50-99+	Not available	Not available	Used in both primary and secondary gas cleaning operations

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[a] Data presented as range from worst to best cases. Efficiency for most systems would be expected to lie between the two extremes.

[b] For all four methods listed removal efficiency is adequate for use in most utilities and industrial plants, rock product operations, steel industries, mining and metallurgical operations; there are limiting applications to some operations such as refinery catalyst recovery, municipal incineration, and plastic production.

[c] Need further testing to confirm these data.

[d] This wide range of efficiencies is a result of variations in fine particulate collection with scrubber pressure drop. The high efficiencies require very high energy inputs into the scrubber.

order to find the best control device for each industrial category. In-plant evaluations of the performance of these devices is underway and is expected to continue through 1979.

2. Recent field tests of the capability of electrostatic precipitators for control of fly-ash emissions from coal-fired utility boilers have shown that collection efficiencies of more than 90% may be possible for particulate fractions down to 0.02 microns.[38] Assessment of ESP performance on these and other sources is continuing in anticipation of the need to adopt performance standards for fine particulate emissions.[39] Similar performance has been obtained with ESPs on a utility boiler and a Cat-ox reactor, indicating that effective fine particulate control for a variety of sources may be achievable with ESPs.

3. Development programs for over 20 novel particulate collection concepts have begun,[39] and the plans include pilot demonstration testing of the more promising of these to be run during 1976 through 1978. The candidate concepts include charged droplet scrubbing, flux force/condensation scrubbing, sonic agglomeration, steam-hydro scrubbing, foam scrubbing, granular bed filtration, and the use of filter beds combined with electrostatic charging of the particles. Definite prognoses for performance capabilities of devices based on most of these concepts are not yet available, but major improvements in collection efficiency of fine particulates are expected. The steam-hydro scrubber, for example, has been found to be highly efficient in a test on an open-hearth steel furnace in which it exhibited a removal efficiency of greater than 90% (mass basis) for all particulate-size fractions above about 0.2 microns.

Though considerable progress has been made in recent years in the measurement and characterization of particulates, not a great deal has been accomplished in the measurement of particles of micron and submicron size.[40,41] Of the various techniques (such as impactors, cyclones, diffusional methods) presently available for the characterization of particulates either by mass or size distribution, most fail to give reproducible results for particles smaller than about 1 micron or for concentrations below about 1 gm/m^3. In addition, accurate data on the fractional efficiency of particulate removal in commercial equipment are very meagre or inconclusive.

Among the various devices for measurement of particle size distributions impactors appear to show most promise.[42] Reliable measurements with impactors, when properly conducted, can be made for particle sizes of about 0.2 microns. To extend the measurement capabilities to even smaller particles, the Southern Research Institute recently tested a series of diffusion batteries coupled with condensation nuclei counters to provide particle concentrations and size distributions over a range of about 0.01 to 0.3 microns. Although results obtained in these two test programs are quite encouraging, a major effort is still needed before these methods can be developed to the point where they are suitable for enforcement of fine particulate standards.

For the most part fine particulate measurement technology is still at an early stage of development. In present investigations work in five different areas is underway:

1. Generation of data bases for emissions of submicron particles from major industrial sources.
2. Improvement of the existing measurement techniques (particularly impactors and optical devices) and development of compact and rapid readout systems.
3. Development of specialized instrumentation for measurement of particulates containing potentially toxic substances including sulfate-containing compounds, trace elements, and carcinogenic hydrocarbons.
4. Evaluation of new concepts for measurement of fine particulates from different types of sources.
5. Development of techniques capable of measuring and analyzing particles that are present in reactive, damp, and high-temperature gases.

Research studies directed toward these objectives are expected to continue through 1979.

5.1.4 Dual Emission Control Systems

This section provides a brief overview of the currently available strategies that can be used to control the emissions of two or more pollutants by a single operation. The intention here is to identify some of the potential benefits that may result from the utilization of such dual emission control systems and to discuss the feasibility of employing such control methods for achieving existing and planned emission control objectives.

The concept of employing a single device to control emissions of multiple pollutants has been used for many years. As indicated by a number of investigations of scrubbers for SO_2 removal, a significant amount of NO_x and particulates present in the flue gas can also be removed.[43,44] The sludge and associated liquors produced by scrubbing have been found to contain certain trace elements, chlorides, and other volatile trace metals present in the feed coal. Recent data show that certain SO_2 scrubber systems, such as the marble-bed absorber[45] and the turbulent contacting absorber,[46] are also capable of removing up to 90% (even more under some conditions) of the particulates with diameter 2 μ or less.*

Since aqueous scrubbers are being installed on many sources emitting both sulfur dioxide and particulate matter, characterization of the performance of these systems with respect to SO_2 and particulate removal efficiency is of considerable importance. This is an active area of investigation, and much new data on dual SO_2-particulate control should become available in the next two years.

Of the various approaches to NO_x control, flue gas cleaning is regarded as the least feasible. To date, little effort has been spent on development of this approach because of this. The only flue gas cleaning methods now deemed feasible are those that remove SO_x in addition to NO_x. Of these, the Japanese Chiyoda Thoroughbred CT102 scrubbing process[47] appears to be the most likely possibility for commercial application.

In the early work carried out on aqueous scrubbing system the amount of NO_x removed was generally 20% or less of that ordinarily found in flue gas. Nevertheless, techniques are available that can significantly improve the removal efficiency of these oxides through scrubbing. It is known that by increasing the NO_2/NO molar ratio in flue gas from its normal value of 0.1 to an equimolar ratio, the absorption of NO_x can be greatly improved. Different techniques for achieving nearly equimolar concentrations of NO_2 and NO in flue gas have been examined extensively. They include: 1) catalytic oxidation of NO, 2) addition or recycling of NO_2 to the flue gas, and 3) homogeneous oxidation of NO with ozone or chlorine added. Of the first two techniques, much research effort will be required before they are technically and economically feasible for industrial use. The known catalytic oxidation techniques are either too slow or too costly[48] and the addition of NO_2 to improve NO_x absorption does not appear promising.[44] With regard to the third technique, the CT102 process has met with some success. This process is a modification of the standard CT101 FGD system[49] in which ozone is added to the stack gas stream prior to scrubbing. The results of pilot plant studies of this system indicate that removal of up to 90% of SO_2 and 60-80% of NO_x can be achieved. Since the amount of NO_x removed in CT102 is directly proportional to the ozone added, the amount of commercial use of the process will depend to a large extent on the availability and cost of ozone. Furthermore, demonstration of the general applicability of the process and further testing of its reliability on a larger scale, especially for large coal-fired boilers, will be necessary before the process is an accepted industrial control technology.

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*This capability is considered an important requirement of fine particulate control technology, since in most power plants a significant fraction of the particles emitted are in the submicron range.

Another area of development of dual control systems for NO_x and SO_x emissions is the work on fluidized bed coal combustion.[50,51] Because of the large heat transfer rates that are possible in fluidized beds, the combustion can be carried out at a lower temperature than is possible in conventional combustors. The rate of nitrogen oxides emission is thereby reduced considerably. With the introduction of dolomite to the combustor, high removal of sulfur (greater than 90%) and a low NO level (less than 150 ppm) can be achieved. Although the development of the fluidized bed combustor will not reach the commercial stage before 1980, its potential for becoming an environmentally and commercially acceptable coal utilization technology is worth watching.

In summary, processes capable of simultaneous reduction of two or more pollutants appear to be a trend in the development of future control technology. All of the processes mentioned in this section are still in one stage or another of pre-commercial development. Nevertheless, it is likely that several of these processes will be developed successfully as the need for more cost-effective processes grows. Much more data on the performance of these processes and evaluations of their expected usefulness are expected in the next few years.

5.2 BASIC RESEARCH EFFORTS

In future efforts to develop control technology for the removal of sulfur oxides, nitrogen oxides, and particulates from industrial process gas streams, it is important that equipment designs be based on adequate understanding of the physical and/or chemical processes responsible for the separation. Basic research in industry is often regarded as not useful, and the approach of manufacturers to control technology development is usually highly empirical. Technology development often proceeds without knowledge of the actual separation mechanism involved and/or without a full recognition of the process limitations under specific operating conditions. Since the costs of empirical experimentation are often considerable, it is prudent to make use of information obtained from conceptual and analytical studies in technology development programs.

Recently, this trend has reversed somewhat as the requirements for cleaner stack gas have become more stringent. In the case of particulates the situation has become rather critical. It has been observed that conventional dust collectors are generally ineffective for controlling emissions of particles having diameters below about 2 microns. In some instances, as when using scrubbers, the collection efficiency can drop to near zero for particle sizes below 0.5 microns.[38] In two recent IERL studies of fine particulate control by flux-force/condensation scrubbing and electrostatic augmentation,[52] entrainment of water droplets was found to be a major problem. As a result a program of theoretical and experimental research on entrainment separator technology was initiated to find a solution to the problem.

It is evident, based on this and similar recent experiences, that fundamental research on process gas cleaning must be undertaken as part of the continuing effort to develop improved control equipment. EPA, ERDA, and EPRI are currently sponsoring the following research in support of control technology development programs:

1. Determination of the importance of particle/liquid interfacial properties to collection of fine particulates by wet scrubbing.
2. Studies directed toward establishing the basic structures of coal, thereby providing a basis for development of more effective chemical cleaning processes for coal.
3. Determination of (a) the contribution of fuel-bound nitrogen to NO_x in coal and oil combustion, (b) the mechanisms and kinetics of converting fuel-bound nitrogen to NO_x, and (c) the fate of fuel-bound nitrogen that is not converted to NO_x.

4. Development of standard laboratory resistivity apparatus and procedures for fine particulate characterization; determination of essential parameters for the prediction of ESP performance through a computer simulation study; identification of the important mechanical problems responsible for ESP operating failures.

5. A study to isolate and identify the nature of organic sulfur, mineral, and trace metal compounds in coal.

6. Determination of the effectiveness of combustion modification techniques for controlling emissions of NO_x, SO_x, HC, CO, and particulates from utility boilers.

7. Identification of the limitations on retrofitting flue gas desulfurization and/or other pollution control devices on existing plants.

5.3 SUMMARY AND CONCLUSIONS

The objectives of this section are threefold:

1. To provide a brief state-of-the-art review of currently available emission control methods.

2. To describe the near-term technological developments expected from current research and development programs.

3. To identify among these expected developments those most likely to find commercial application by 1980.

Most of the control technologies discussed are for coal combustion in industrial and utility boilers. Emissions of primary concern are sulfur oxides, nitrogen oxides, and particulates. Special attention is given to fine particulate emission control and measurement. Processes also included are those that have dual or multi-pollutant control capabilities.

The conclusions obtained in this review can be stated first by identifying the best available emission control techniques for sulfur oxides, nitrogen oxides, and particulates, and second by giving a forecast of developments expected from current research efforts and a list of areas where further research is required.

1. In regard to process availability, process reliability, pollutant removal efficiency, costs, and lead times for installation, it is apparent that:

a. The majority of sulfur oxide removal systems installed or planned in this country are of the flue gas desulfurization (FGD) type, over 70% of which are lime/limestone scrubbers. However, it is doubtful that the capacity of the scrubber manufacturing industry is adequate to meet more than 10% of the anticipated demand through 1980.[53]

b. The approach to reduce NO_x formation in any combustion process will be mainly through combustion modification.

In the case of particulate control the choice among the three basic processes (i.e., ESP, fabric filtration, and wet scrubbing) is less obvious. The main factor inhibiting the choice is the inefficiency of each of these systems for removing particles in the submicron size range. Much research and experience are still required to find a system capable of collecting fine particles.

2. In view of EPA's and EPRI's current technology development plans and their resource utilization patterns in support of the various sections in the Clean Air Act (109, 110, 111, 112, and 113), the near-term (prior to 1980) technological achievements will include the following:

   a. For sulfur oxide emission control: 1) solutions of the problems of disposal or utilization of waste sludges from non-regenerable FGD scrubbing systems; 2) continued progress on development of FGD systems of the regenerable type, with one or more expected to be commercially available by 1980.

   b. For NO_x emission control: current research efforts are expected to lead to modifications of operating procedures and equipment in utility and industrial boilers that reduce NO_x emissions. There is insufficient information at the present time to predict which modifications will prove most effective and what level of control will be ultimately achievable.

   c. For fine particulate emission control: 1) continued improvement on instruments for the characterization of fine particulates by total mass, chemical composition, and size distribution; 2) modification of existing techniques and development of novel systems for effective removal of submicron particles down to 0.001 microns in diameter.

3. The following are the areas for which a substantial increase in the amount of research effort is needed:

a. Dual or multi-emission control systems: to determine the removal capability for all pollutants of current control systems including those still under development; and to explore new concepts for existing or novel devices by which dual or multi-emission control might be obtainable.

b. Basic research: the need is to improve and upgrade present pollutant control systems using information about the fundamental processes that effect the removal of the pollutant from the stack gas.

6. PROCEDURES FOR DEVELOPMENT OF NEW SOURCE PERFORMANCE STANDARDS

Preceding chapters have discussed the impact on future levels of emission control that results from setting priorities based on factors such as pollutant health and welfare effects, availability of control and measurement technology, cost of control, emission rates, growth rates, source location, energy conservation, and existing regulations. In this section is evaluated various aspects of the EPA standard setting and implementation procedure and the impact of these and alternative procedures on the rate of standard-setting and resulting projected emission levels.

The procedural requirements contained in Section 111 of the Clean Air Act for the development and promulgation of NSPS are limited to the following basic schedule (Section 111(b) (1)):

1. Publication of a list of categories of sources that contribute significantly to air pollution that causes or contributes to the endangerment of public health or welfare.
2. Within 120 days after publication of the list, proposed regulations are to be published.
3. After a 90-day comment period, the proposed regulations with approproate modifications are promulgated.
4. Standards may be revised as necessary using these same procedures.

In actual practice, the full process of establishing standards follows the procedure outlined in Fig. 6-1. Phase I of the process, Source Priority Determination, includes as a major element prioritization of all possible standards as is discussed and implemented in Sections 3 and 4 of this report. Additional aspects of priority determination are discussed in the following section.

Prior to making a commitment to the development of standards for a source category, it is generally useful to conduct industrial surveys and to establish contacts through appropriate trade associations or other industry representatives to gain information relating to current status of emission control, expected industry growth, and other factors (Phase II).

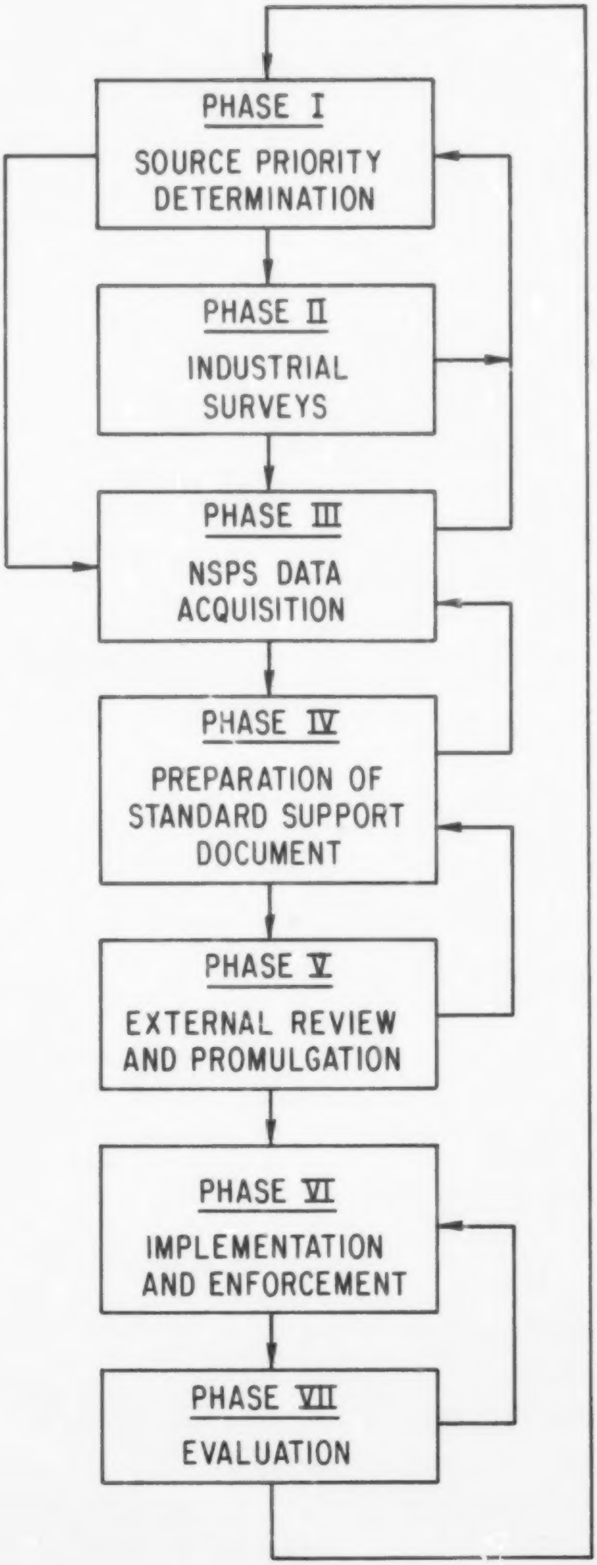
PHASE I
SOURCE PRIORITY DETERMINATION
PHASE II
INDUSTRIAL SURVEYS
PHASE III
NSPS DATA ACQUISITION
PHASE IV
PREPARATION OF STANDARD SUPPORT DOCUMENT
PHASE V
EXTERNAL REVIEW AND PROMULGATION
PHASE VI
IMPLEMENTATION AND ENFORCEMENT
PHASE VII
EVALUATION

Fig. 6-1. Procedures for Development and Implementation of NSPS

The procedures for data acquisition (Phase III) and establishing a recommended standard (Phase IV) are discussed further in Section 6.2. Section 6.3 discusses the review by EPA and others which culminates in a promulgated standard (Phase V). Implementation and enforcement of the standard (Phase VI) and the subsequent evaluation of needs for revision (Phase VII) are the topics of Section 6.4.

From previous experience, the time required from the start of the data acquisition (Phase III) through standard promulgation (Phase V) can be sixteen months or more, and evaluation of the standard's effectiveness through the evaluation of new sources regulated by the standard will require an additional 2-5 years. This long time span between start of standard development, its evaluation, and the process of revising a standard (another 16 months) emphasizes the importance of selecting categories for standard setting with largest impact, establishing the most stringent standard possible, and maintaining a tight standard development schedule.

For the development of standards for each category, approximately 75-95 man-weeks of effort are required for industrial evaluation, cost analysis, and emissions measurement (not including assistance of subcontractors for emissions measurement). In addition, the review process and preparation of materials for publication of proposed and final standards in the Federal Register requires an additional 10-20 man-weeks for a total of 85-115 man-weeks per standard.

6.1 *SOURCE PRIORITY DETERMINATION AND SCHEDULING STANDARD DEVELOPMENT*

The determination of source priorities (Phase I, Fig. 6-1) consists of two rather distinct levels:

Level 1. An initial prioritization of all possible standards.

Level 2. A detailed prioritization of a limited number of the higher priority categories identified.

This study, building on the TRC data provided,[4] is a Level 1 prioritization. Because of the somewhat cursory analysis of each category to which this study was limited, the more detailed Level 2 evaluation is required for final prioritization.

For the Level 2 detailed prioritization the high ranking categories in each of the constraint groups identified in the individual pollutant evaluations in Section 4.2-4.6 are to be considered. Evaluation of top categories in each of the constraint groups provides a check on the validity of a constraint factor for a category that may have a high ranking based on Ts-Tn alone.

Because of unavoidable changes in factors upon which source priorities are based, the process of establishing priorities as described in Section 3 must be an iterative and on-going function of the standard-setting procedure. Priorities will necessarily change as a result of changes in goals for stationary source emission control, decisions to control additional pollutants, new developments in emissions control and measurement technology, and availability of clean fuels. Source priorities must also be reevaluated periodically because of additional information made available to the EPA concerning the industry emission factors and control methods applicable to that industry. The prioritization process in Section 3 is designed so as to easily allow reevaluation of priorities and expected emissions under different assumptions and criteria. Subsequent prioritizations could also be linked to other EPA data, such as the SIP reviews and SAROAD files on emissions and air quality, which may be more precise in defining needs for standards for specific pollutants and categories.

Industry categories that are already regulated by NSPS should also be included in the future priority analysis if changes in control or process technology, for example, make possible a revised standard that is more stringent.

Because of changing priorities, a decision-making methodology is required for defining when it is desirable to delay completion of a standard under development because of a priority change and when it is more advantageous to continue in spite of the change. The standard-setting priority analysis method can be used for this purpose by including in the priority analysis the industry category for which a standard is in the process of being developed. In this situation the time for standard development (t_{SD}), the priority factor introduced in Section 3.2.1, becomes the time required only to complete the standard.

The possible desirability of delaying completion of standard development in certain cases has an impact on the type of contract written when the standards development is performed by contractors. The most efficient type of contract is one covering the entire preparation of the Standards Support Document draft. However if there is uncertainty in the priority ranking, a phased contract would have the advantage of allowing delays in completion to account for the change in priorities. Each phase of such a contract would be designed to supply sufficient information to allow a priority reevaluation before proceeding with the subsequent phase.

A guideline for making the decision between a full commitment to develop a standard for a source category or collecting more preliminary information to support such a commitment can be obtained by analyzing the impact on the priority factor (Section 3.4) of the inaccuracy in the emission factor and growth and production factor estimates. In the most obvious case, if the uncertainty in priority factor for two categories is less than the difference between their respective priority factors, a full commitment to the higher priority category is possible.

In the case of a category with high priority factor, but also large uncertainty bounds which overlap the value of the next lower priority factor, a preliminary study to remove the uncertainty in priorities may be indicated. However, an additional consideration is the estimated time required for standard development that appears in the denominator of the priority factor; the preliminary analysis will increase the priority factor, assuming that the subsequent development will be shortened as a result of that preliminary analysis. A possible result is that the category with the higher priority factor will retain the higher priority even if the original estimate was in error. In other words, the effect on the priority factor of bringing the category nearer to promulgation may more than offset the error in the original estimate of the factor and a commitment to full standard development without preliminary analysis would be preferred.

The above discussion suggests the usefulness of including an indication of expected error bounds in the initial evaluation of priorities. Such an estimate of error, although not a part of this study, could be implemented based on an accuracy ranking.

Previous sections of this report have emphasized the importance of developing standards at the earliest possible date to minimize the number of sources not regulated because of construction or modification commencing prior to standard promulgation. Because of this objective there may be a tendency to initiate standards development for too many categories, which can lead to counterproductive results as illustrated by the following simple example.

Consider two unrelated categories with comparable emission and growth factors and equal times, Δt, required for standard development, and as a result equal priority. Assume that the available EPA resources can be allocated to (1) develop the standards serially such that one standard is promulgated at time Δt and the second is promulgated at time 2Δt, or, (2) develop the standards in parallel such that both standards are promulgated at time 2Δt. Clearly the serial development results in lower emissions for this example because of the earlier standard setting for the first category.

The conclusion to be drawn on the basis of this example is that effort should be concentrated on the higher priority sources to the extent that maximum rate of development is achieved. This provides an argument against the development of standards in groups that are to be promulgated simultaneously. Each standard is to be developed individually at its own maximum rate. There is of course a limit on the rate of development and when that rate has been achieved remaining resources can be allocated to standard development for lower priority categories. Decreasing the emphasis on serial development was simulated by Strategy 14 in Section 4.7 by increasing the time increment between standards plus a corresponding increase in number of standards at each discrete point in time. The result was a small but noticeable increase in emissions.

A counter argument in favor of parallel development occurs in the case where efficiency results from simultaneous analysis of two or more related categories. The benefit from simultaneous development can be difficult to assess, in particular if one of the categories is being shifted to a higher or lower priority for the purpose of simultaneous development. The gain or loss in emission control for such a case can most directly be determined by using the priority impact analysis tools discussed previously.

The prioritization of categories forms the basis for developing a program plan for carrying out the various tasks related to standard promulgation.

At a high rate of standard development, the proper sequential planning of the necessary tasks and allocation of available manpower and resources can become quite cumbersome. In recent years, various computer systems have been developed that provide automated management assistance based on techniques such as critical path analysis, resource allocation, and PERT.[14,15] These management tools should be further evaluated as to their usefulness in NSPS scheduling.

6.2 PROCEDURES AND RATIONALE FOR DEVELOPMENT OF NSPS

Under the mandate of Section 111 of the Clean Air Act, the EPA has promulgated or proposed, since the passage of the Act in 1970, about 34 NSPS for pollutants in 21 source categories. During the course of those actions, there has evolved a series of guidelines for the process of establishing NSPS. The following is documented description of those guidelines:[16]

> Congress mandated that sources regulated under section 111 of the Clean Air Act be required to utilize the best practicable air pollution control technology that has been adequately demonstrated at the time of their design and construction. In so doing, Congress sought to:
>
> 1. maintain existing high-quality air,
> 2. prevent new air pollution problems, and
> 3. ensure uniform national standards for new facilities.
>
> The selection of standards of performance to achieve the intent of Congress has been surprisingly difficult. In general, the standards must (1) realistically reflect best demonstrated control practice; (2) adequately consider the cost of such control; (3) be applicable to existing sources that are modified as well as new installations; and (4) meet these conditions for all variations of operating conditions being considered anywhere in the country.
>
> A major portion of the program for development of standards is spent identifying the best system of emission reduction which "has been adequately demonstrated" and quantifying the emission rates achievable with the system. The legislative history of section 111 and the [subsequent] court decisions make clear that the Administrator's judgment of what is adequately demonstrated is not limited to systems that are in actual routine use. Consequently, the search may include a technical assessment of control systems which have been adequately demonstrated but for which there is limited operational experience.

To date, determination of the "degree of emission limitation achievable" has been commonly based on (but not restricted to) results of tests of emissions from existing sources. This has required worldwide investigation and measurement of emissions from control systems. Other countries with heavily populated, industrialized areas have sometimes developed more effective systems of control than those used in the United States.

Because the best demonstrated systems of emission reduction may not be in widespread use, the data base upon which the standards are established will necessarily be somewhat limited. Test data on existing well-controlled sources are an obvious starting point in developing emission limits for new sources. However, since the control of existing sources generally represents retrofit technology or was originally designed to meet an existing State or local regulation, new sources may be able to meet more stringent emission standards. Accordingly, other information must be considered and judgment is necessarily involved in setting proposed standards.

Since passage of the Clean Air Amendments of 1970, a process for the development of a standard has evolved. In general, it follows the guidelines below.

1. Emissions from existing well-controlled sources are measured.

2. Data on emissions from such sources are assessed with consideration of such factors as: (a) the representativeness of the source tested (feedstock, operation, size, age, etc.); (b) the age and maintenance of the control equipment tested (and possible degradation in the efficiency of control of similar new equipment even with good maintenance procedures); (c) the design uncertainties for the type of control equipment being considered; and (d) the degree of uncertainty affecting the judgment that new sources will be able to achieve similar levels of control.

3. During development of the standards, information from pilot and prototype installations, guarantees by vendors of control equipment, contracted (but not yet constructed) projects, foreign technology, and published literature are considered, especially for sources where "emerging" technology appears significant.

4. Where possible, standards are set at a level that is achievable with more than one control technique or licensed process.

5. Where possible, standards are set to encourage (or at least permit) the use of process modifications or new processes as a method of control rather than "add-on" systems of air pollution control.

6. Where possible, standards are set to permit use of systems capable of controlling more than one pollutant (for example, a scrubber can remove both gaseous and particulate matter emissions, whereas an electrostatic precipitator is specific to particulate matter).

7. Where appropriate, standards for visible emissions are established in conjunction with mass emission standards. In such cases, the standards are set in such a way that a source meeting the mass emissions standard will be able to meet the visible emission standard without additional controls. (In some cases, such as fugitive dust, there is no mass standard.)

Finally, when all pertinent data are available, judgment is again required. Numerical results should not be transposed directly into regulations. The design and operating conditions of those sources from which emissions were actually measured cannot be reproduced exactly by each new source to which the standard of performance will apply.

Section 111 of the Clean Air Act requires that cost be considered in setting standards of performance. To do this requires an assessment of the possible economic effects of implementing various levels of control technology in new plants within a given industry. The first step in this analysis requires the generation of estimates of installed capital costs and annual operating costs for various demonstrated control systems, each control system alternative having a different overall control capability. The final step in the analysis is to determine the economic impact of the various control alternatives upon a new plant in the industry. The fundamental question to be addressed in this step is whether or not a new plant would be constructed given that a certain level of control costs would be incurred. Other issues that would be analyzed in this step would be the effects of control costs upon product prices and the effects on product and raw material supplies and producer profitability.

The economic impact upon an industry of a proposed standard is usually addressed both in absolute terms and by comparison with the control costs that would be incurred as a result of compliance with typical existing state control regulations. This incremental approach is taken since a new plant would be required to comply with state regulations in the absence of a federal standard of performance. This approach requires a detailed analysis

> of the impact upon the industry resulting from the cost differential that usually exists between the standard of performance and the typical state standard.
>
> It should be noted that the costs for control of air pollutants are not the only control costs considered. Total environmental costs for control of water pollutants as well as air pollutants are analyzed wherever possible.
>
> A thorough study of the profitability and price-setting mechanisms of the industry is essential to the analysis so that an accurate estimate of potential adverse economic impacts can be made. It is also essential to know the capital requirements placed on plants in the absence of federal standards of performance so that the additional capital requirements necessitated by these standards can be placed in the proper perspective. Finally, it is necessary to recognize any constraints on capital availability within an industry as this factor also influences the ability of new plants to generate the capital required for installation of the additional control equipment needed to meet the standards of performance.
>
> The end result of the analysis is a presentation of costs and potential economic impacts for a series of control alternatives. This information is then a major factor that the Administrator considers in selecting a standard.

During the course of developing and implementing the above procedures for standard development, the successive background information documents have shown a definite trend toward providing more detail and comprehensiveness. Although this implies increased effort for the standard development, the result has been in general standards that are more easily defendable. This increased effort for each standard results in fewer standards being promulgated, but on the basis of the analysis in Section 4 relatively small increases in rate of standard-setting do not have a significant impact on total national emissions. In fact, less detailed supporting documents could lead to less stringent standards causing the increased standard-setting rate to be counterproductive.

The question of how sources should be subcategorized and how affected facilities within a subcategory should be selected and the resultant impact on emissions controlled is not an issue that can be answered in general because of the opposing effects of increased efficiency in standard development for similar sources and the possible lower priority for some of the sources in the combined category. The most direct approach to this issue is to delineate alternative subcategorizations and evaluate the impact using the analysis tools described previously.

Although not legally required, a possible useful addition to the cost analysis is an evaluation of the cost of control per unit weight of pollutant removed as a result of the standard. This estimate along with similar estimates for other standards would provide a coarse indication of the cost effectiveness of the standard. A cost evaluation based on final product-cost impact alone could show as acceptable an excessively large cost for a small emission reduction if the cost were distributed throughout a large industry.

6.3 REVIEW OF PROPOSED NSPS

Following development of the initial draft of the standard support document, comments are solicited from a wide variety of groups and individuals from within the EPA, other Federal agencies, affected industries, and other interested persons, in order to provide adequate opportunity for input from divergent sources of information (Phase V). This aspect of the standard setting procedure is crucial to the development of a defendable standard but tends to be time-consuming and is usually an important consideration in the scheduling of final standard promulgation. A proper balance must be established between the need to provide an adequate hearing to divergent interests and the need to promulgate standards at the earliest possible date.

The legal requirement for involvement of interested parties in setting NSPS is defined in Section 111 of the Clean Air Act as discussed in the introduction to this chapter. The EPA must first publish (in the Federal Register) a list of categories for which it intends to establish NSPS, thus giving interested parties an initial opportunity to comment on EPA source priorities. After submitting a proposed standard, the EPA must promulgate final standards following a period of not more than 90 days during which comments from interested parties are publicly solicited, and if valid, incorporated into the standards.

Additional specific requirements for standards review are defined in the Clean Air Act in Sections 117 (d) and 117 (f):

> (d) In order to obtain assistance in the development and implementation of the purposes of this Act, including air quality criteria, recommended control techniques, standards, research and development, and to encourage the continued efforts on the part of industry to improve air quality and to develop economically feasible methods for the control and abatement of air pollution, the Administrator shall from time to time establish advisory committees. Committee members shall include, but not be limited to, persons who are knowledgeable concerning air quality from the standpoint of health, welfare, economics, or technology.
>
> (f) Prior to -
> ...(2) publishing any list under section 111(b)(1) (A) or 112(b) (1) (A),
> (3) publishing any standard under section 111(b)(1)(B) or section 112(b)(1) (B),
> ...the Administrator shall, to the maximum extent practicable within the time provided, consult with appropriate advisory committees, independent experts, and federal departments and agencies.

The continuing procedure used by the EPA for obtaining information from industrial interests is through direct contact with representatives from trade associations, equipment vendors, and individual companies. As shown in Fig. 6-1, the contact with industrial representatives is one of the first steps in the standard-setting procedure and generally precedes a firm commitment to develop an NSPS for the industry. Examples of associations that have contributed information to the standards development process are the American Boiler Manufacturer Association, the Edison Electric Institute, the American Iron and Steel Institute, the American Petroleum Institute, the National Asphalt Pavement Association, the Portland Cement Association, and the Industrial Gas Cleaning Institute. These industry-related contacts are not only part of the review process but are used extensively in the development of the initial draft of the standard support document.

Detailed internal EPA review is provided by a "working group" and "steering committee." The working group, which assists in the formulation and implementation of an NSPS development plan, includes representatives from EPA organizations involved with enforcement, research, water effluents, solid waste, legal council, and economic analysis. The steering committee, chaired by the EPA/Office of Planning and Evaluation, is responsible for reviewing the progress of standards at several key milestones. Approval by the EPA Administrator and Assistant Administrator for Air Programs is also required.

In compliance with the intent of Section 117 of the Clean Air Act given above, the standards are reviewed in detail externally to the EPA by the National Air Pollution Control Techniques Advisory Committee (NAPCTAC) and by other federal agencies. The NAPCTAC members represent industry, control equipment manufacturers, regional air pollution control agencies, and consultants specializing in air pollution control. Frequently individuals with expertise related to the specific source category being considered are invited to participate in committee meetings as technical consultants.

The function of federal agency review is to provide input into the standard development in view of the possible impact on their respective programs. This review process is coordinated by the Office of Management and Budget.

Because of the large number and diversity of interests by necessity represented in this review procedure, there exists the danger of the review process becoming excessively long because of delays in reviewers' response and revisions piling on top of revisions as separate interested parties attempt to prevail with opposing views. As an indication of the possible impact of delays in the review of standards prior to being proposed in the Federal Register, during an eight-month period prior to promulgation of the second group of standards, construction was initiated, and thus the NSPS did not apply, for approximately 140 asphalt concrete plants, 40 sewage sludge incinerators, 2 petroleum refineries, and 300 storage tanks. This translates into an emission penalty of more than 10,000 tons of particulates, 5000 tons of SO_2, and 14,000 tons of hydrocarbons per year.

To prevent such extensive delays, the EPA must establish firm schedules for receipt of reviewers' comments and clearly indicate that consideration of these comments depends on schedule maintenance. Having received reviewers comments, the EPA must then formulate and publish a proposed standard on the basis of best available information. Reviewers will then have a second opportunity for comment prior to promulgation.

A nominal schedule currently used by EPA for review following initial drafting of the background document is given in Table 6-1, and an accelerated schedule is given for comparison in Table 6-2. The current and accelerated schedules indicate 37 and 27 weeks, respectively, for review prior to promulgation. However, more importantly, the respective time periods in the two schedules prior to publishing the proposed standard are 28 weeks and 15 weeks. The effective date for a NSPS is the date on which the proposed standard was first published (Section 111(a)(2) of the Clean Air Act) and thus there is no advantage to shortening the time for comments following the proposed standard publication. In view of this, the accelerated schedule has a lengthened comment period following proposal publication to offset the shortened time prior to publication.

The first major change in the accelerated schedule is the earlier time (8 weeks vs. 12 weeks) for the completion of "Receipt and evaluation of comments" following the presentations to the Working Group, NAPCTAC, other federal agencies, and industry. This schedule is reasonable if these groups are given for review initial draft background document immediately after completion. If the initial draft of the document is completely developed by a contractor, delays in distribution of the document and in the overall schedule may result from preliminary EPA review of the document. An alternative that avoids this delay is the distribution of the unedited contractor's report marked with an EPA disclaimer. (This procedure has been used by the EPA Effluent Guidelines Division in the development of water effluent standards.) EPA review of the contractor's document can proceed in parallel with the review of other groups and EPA suggested revisions could be sent to the review groups prior to the formal meetings. These revisions should not be major if the EPA has maintained close contact with the contractor during the background document development.

The second major change in the accelerated schedule is the absorption of the major steering committee functions by the Working Group. As experience is accumulated and the standard development procedure and rationale become more firm, the inputs required from these advisory groups are expected to decrease as related to specific standards. The need for input from these groups related to long-term priorities and scheduling is, however, expected to continue.

Table 6-1. Current EPA Schedules for Review And Promulgation of NSPS

Activity	Completion Date, Weeks
First draft of Standard Support Document	0
Presentations to Working Group, NAPCTAC, Other Federal Agencies, Industry	5-1/2
Receipt and evaluation of comments	12
Second presentation to Working Group	13
Draft of proposed standard and briefing document	16
Review by Steering Committee and AA/OAWM	22
Review by Administrator	25
Publish proposed standard	28
Solicit comments from Federal Agencies	31
Evaluate comments and forward to AA/OAWM, OMB	33
Final action by Administrator	36
Promulgate final standard	37

Table 6-2. Accelerated EPA Schedules for Review and Promulgation of NSPS

Activity	Completion Date, Weeks
First draft of Standard Support Document	0
Presentations to NAPCTAC, Other Federal Agencies, Industry	4
Receipt and evaluation of comments	8
Draft of proposed standard and briefing document	10
Review by Working Group and AA/OAWM	11
Review by Administrator	13
Publish proposed standard	15
Solicit comments from Federal Agencies	18
Evaluate comments and forward to AA/OAWM, OMB	23
Final action by Administrator	26
Promulgate final standard	27

Although the accelerated schedule in Table 6-2 represents a decrease in the time required to promulgate standards, the effort required by the EPA in terms of total man-weeks will not change in direct proportion but rather the number of staff involved in the review process at any one time will need to be increased somewhat.

The feasibility of the accelerated schedule can partially be evaluated by comparison with the EPA Effluent Guidelines Division review schedule that has been implemented for setting water effluent standards of performance. The scheduled time from completion of the initial background document draft to publishing the proposed standard for that group is 13 weeks as compared to 15 weeks in the accelerated schedule in Table 6-2. The reader must, however, keep in mind the different constraints involved in setting effluent standards. In particular, the strict schedule for effluent standards demanded by a court order is a convincing argument to require reviewers to maintain a tight schedule in submitting comments. Also, prior to implementing a similar schedule for NSPS development, a detailed evaluation of the effectiveness and problems of the Effluent Guidelines Division's program should be made.

6.4 INVOLVEMENT OF CONTRACTORS IN STANDARDS DEVELOPMENT

A broad range of alternatives is available in the use of contractors in the development of NSPS. An overriding factor, of course, in the decision to use contractors is the availability of funds in addition to those required to support present in-house projects. Assuming that additional funds are available for the development of NSPS, use of contractors must be weighed against the option of increasing in-house manpower resources.

The primary motivations for the use of contractors in the development of standards are:

1. The limitations on available manpower are relaxed in terms of both numbers and expertise in selected subject areas.
2. Involvement of outside personnel can broaden the overall perspective on standard setting issues.
3. Major alterations in funding levels can be more easily accommodated.

These advantages are offset by the disadvantages of:

1. Extra time requirements of writing requests for proposals, negotiating contracts, and monitoring performance.
2. Risk of inadequate performance by a contractor.
3. Future difficulties related to not having developed in-house expertise.
4. Commitments of funds to contractor studies reduces flexibility to shift goals or emphasis.

In order to establish effective policies in the use of contractors in view of the above advantages and disadvantages, the following basic precepts will be useful.

The range of levels for in-house funding should consider long-range needs. As a minimum, the EPA must develop a sufficient base of expertise to defend promulgated standards in legal challenges and to evaluate standards in post-promulgation reviews for consideration of possible revisions or additions covering new categories. As a coarse estimate, one staff person can become sufficiently knowledgable to perform these post-promulgation activities for 4 to 8 categories (depending on the assistance obtained through contractors) and there are approximately 200 categories, and thus the future EPA manpower needs in this area will be in the range of 25-50 staff persons, although short-term needs may indicate larger manpower requirements.

Broad limitations can also be established in regard to the degree of participation in standards development that is desirable by contractors. As a minimum, certain standard development tasks for which the EPA has no current expertise or equipment capabilities and for which, furthermore, it is not in the long-term interest of the EPA to develop these capabilities, should be contracted. Examples of such activities that should be given to contractors are extensive source monitoring using existing methods and economic and social impact analyses for particular standards for Environmental Impact Statements. Organizations, such as the Industrial Gas Cleaning Institute, that have a unique access to information, should also be involved in the standard development procedure.

A second use of contractors is for preliminary studies used to develop information required to finalize source priorities (Phase II) as discussed in

Sec. 6.1. This provides for desirable early involvement of outside expertise in identifying needs for NSPS. This outside contracting would not affect development of EPA expertise, which results primarily from experience gained in compilation of the Standards Support Document in Phase III.

These high priority uses of contractors in supportive tasks and preliminary studies should have only minor impact on cost per standard in comparison to in-house performance of these activities. The costs of contract negotiation and monitoring should be offset by the efficiencies of contractors whose selection is based on prior knowledge and experience.

The most extensive use of contractors is through their assignment of the full responsibility for development of the first draft of the Standards Support Document in Phase III. Allocation of funding for this use of contractors should only be considered after higher priority needs identified above are fulfilled. In spite of the low priority given to this use of contractors, it is the most significant in that it permits the largest increase in rate of standard development without increasing EPA staffing.

Through the use of contractors to completely develop the initial draft on the Standards Support Documents, the maximum number of standards that could be under development at any one time is attained. The upper limit results from the need to avoid pitfalls indicated in the above list of disadvantages of using contractors. The activities of the contractor must be monitored more closely than in a typical EPA-funded contract for the dual purpose of (a) insuring adequate performance as required in a defendable Standards Support Document and (b) allowing EPA to attain adequate expertise related to the source category. In view of these constraints, approximately one half the time of an EPA staff person would be required to oversee the contractor efforts during the approximately 30 weeks required for development of the initial draft Standards Support Document for each category. Assuming subsequent activities related to proposed standard review and promulgation cannot be carried out by contractors, the total EPA staff time required for completing Phases III through VII, Standard Promulgation, is reduced from an average of 100 manweeks for complete in-house development as indicated in the introduction to a minimum of 30 manweeks. For an EPA staff of 30 the standard promulgation rate could thereby be increased to approximately 50 per year.

The assumptions presented above in relation to use of contractors for full Standards Support Document initial draft development result in increased EPA cost per standard. Assuming that the cost for initial draft development is comparable if performed by the EPA in-house or by contractors, the 15 man-weeks effort required by EPA to oversee the contract is the cost increment for using contractors in this manner. However, there is an increased effectiveness by way of reduced emissions resulting from a faster standard-setting rate.

Efficiencies in the use of contractors can be obtained by grouping industries into broad categories and allocating to a single contractor the responsibility to develop initial draft Standards Support Documents for all categories within the grouping. This broader approach allows a more coordinated analysis of related industries and permits the contractor to subcategorize industries in a manner that optimizes effectiveness of NSPS. A possible disadvantage associated with simultaneous development of standards for all categories in a grouping is that the chronological sequence dictated by source priority rankings cannot be strictly followed. However, if the standards are being promulgated at nearly the maximum rate, the loss associated with not following the ranking will not be large.

The practice of grouping similar industries in a single contract study has been used by the Effluent Guidelines Division of the EPA in their development of water-effluent regulations. For example, all industries primarily engaged in production of coal (Standard Industrial Classification Major Groups 11 and 12) were studied under a single contract as were Machinery and Mechanical Products Manufacturing, Mineral Mining, and Processing. Further study of this practice as an NSPS development mechanism is needed to evaluate its effectiveness.

A further implication of a decision to use contractors to completely develop the initial Standards Support Document draft relates to organizational structure of the EPA/ESED staff. The present practice of assignment of Industrial Studies, Cost Analysis, Emissions Measurement, and Standards Development tasks to separate organizational units would not be necessary or desirable since the first three of these tasks would be undertaken by the contractor. The staff person, or team of staff persons, who are monitoring the contractor performance would also be the most appropriate to carry through with the Standard Development since they would have developed the greatest degree of expertise related to the specific category.

6.5 DEVELOPMENT AND REVIEW OF FORMAL NSPS ENVIRONMENTAL IMPACT STATEMENTS

While it is not legally bound to do so, the present EPA policy[17] is to prepare Environmental Impact Statements (EIS) for proposed NSPS and certain other environmentally protective activities because of the resultant benefits. Through evaluation and documentation of both positive and possible negative expected environmental impacts of a proposed standard, the EPA obtains a more substantial information base for decision-making and the proposed standard thus becomes easier to defend and enforce.

The following subsections are a discussion of items that should be given consideration in an EIS for a specific NSPS or for the general NSPS program and how development and review of EIS relates to development and review of the Standards Support Document.

6.5.1 Environmental Impact Analysis Related to a Specific NSPS

The following is a discussion of EIS contents that are necessary for a NSPS. The listed points to be covered closely follows the guidelines issued by the Council on Environmental Quality[18] and EPA.[19]

A description of the proposed action, a statement of its purposes, and a description of the environment affected. The proposed action description is sufficiently presented in other segments of the standard support document. A statement on the purposes of the action is to include estimates of the total emissions from the source with and without NSPS, percentages of total national emissions for the pollutants affected, and the role of the particular standard in the total national, state, and local air quality strategy. Background information on the purpose can be provided by the study on cumulative impacts of NSPS discussed later. Precise information on the location affected cannot, of course, be provided; however, statements as to the general location can be included (e.g., urban or rural). Also, projections based on historical trends can be used to indicate regions expected to be most heavily impacted.

The relationship of the proposed action to land use plans, policies, and controls for the affected area. A NSPS will not in general have a large direct impact on land use plans; however, indirect impacts may occur, such as permitting greater industrial concentration due to reduced unit emissions or restricting options for industrial development due to secondary impacts.

The probable impact of the proposed action on the environment. The positive impacts of reduced air emissions cannot be specified with certainty; however, the range of impacts for any particular application can be estimated in view of expected typical source size, existing regulations, raw material composition, or other relevant factors. Secondary impacts related to, for example, energy consumption, resource commitments, and solid and liquid wastes should be included using as input the general studies discussed below.

Alternatives to the proposed action, including, where relevant, those not within the existing authority of the responsible agency. This section should consider the relative impacts of alternate strategies such as retrofitting, growth control, development of substitute industrial products, or no action.

Any probable adverse environmental effects that cannot be avoided. This should be a brief section summarizing in one place those unavoidable adverse effects discussed previously. A comparison should be made with the expected environmental benefits.

The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity. This section should show how the short-term effect of the NSPS on the affected source economics and operations are related to the long-term benefits that will be accrued as the result of environmental gains from reduced emissions.

Any reversible and irretrievable commitments of resources that would be involved in the proposed action should it be implemented. This refers primarily to an identification of labor and materials that will necessarily be committed to the construction and operation of the emission control system.

6.5.2 *Environmental Impact Analysis with General Applicability*

Certain types of control systems with minor variations represent best available technology for a variety of polluting sources. It would thus be most effective to complete a comprehensive analysis of primary and secondary environmental impacts, including cumulative effects of widespread use, for that control system with only cursory consideration of the specific source applications. The EIS relating to a specific NSPS based on use of that control system could then draw heavily on information from that general environmental analysis.

Wet scrubbers are a prime example of a control system that could benefit from an independent environmental impact study that contains more detail than is possible in the statements for each specific application. A comprehensive wet scrubber environmental impact analysis would include:

1. Characterization of water effluents and treatment technology. The chemical and biological properties of dissolved and suspended solids in the effluent are a function of scrubber size and type, composition of scrubbed gas, maintenance practices, normal and abnormal operating conditions, and composition of lime or other scrubber chemicals. The current state of the art of the technology for treatment of these effluents including settling ponds, chemical removal, closed and open cycles, regeneration, etc. These considerations should be directed as closely as possible to the requirements and objectives of the Federal Water Pollution Control Act of 1972.

2. Environmental impact of primary and secondary energy requirements of scrubbers. Direct energy requirements for the operation of various type and size scrubbers depend on concentration of pollutants in the gas, scrubber efficiency for various size particulates, and scrubbers' age and maintenance practices. The significance of secondary energy requirements such as for production and transport of scrubber chemicals and treatment of water effluents are included. By providing information on the environmental impact of the consumption of a unit of energy including the impact on availability of clean fuels, the energy-related environmental impact of scrubbers can be determined.

3. Solid-waste disposal. The quantities and physical and chemical properties of solid wastes and slurries would be described in detail for various types and sizes of scrubbers in different applications. Of primary concern is the polluting potential of the land fill disposal

in terms of surface water runoff and groundwater contamination. Both short-term and long-term effects require consideration. The possibilities of alternative uses such as processing of wastes for use in construction material should also be evaluated using current knowledge.

4. Resource commitment and recovery. In addition to energy requirements discussed above, the commitment or recovery of other natural resource related to emission control systems must be established. Examples are uses of large quantities of chemicals in once-through systems and the production of sulfur. The environmental impact of production and consumption of these resources are indirect and possibly minor except for localized effects; however, the relative importance must be documented.

Although the potential secondary environmental impacts of other types of air pollution control equipment are not as extensive as for wet scrubbers, these impacts should also be covered in detail in comprehensive studies that could be referenced in environmental statements for specific applications. Of particular importance is the impact of hydrocarbon emission control, which in many applications with current technology requires energy-consuming afterburners. For dry removal systems such as baghouses and electrostatic precipitators, a comprehensive secondary impact evaluation would also be useful; however, the expected impacts in terms of energy requirements and solid-waste disposal are less severe and a less extensive effort is required for the analysis. Effluent treatment and/or disposal must, however, be considered for precipitators utilizing liquids to flush collected particulates.

The cumulative environmental impacts of a group of NSPS may be significant in spite of the fact that the impact from each NSPS taken singly is relatively minor. Consideration of such a cumulative effect will become more important in the future after large sources, which of themselves have a significant environmental impact (e.g., power plants), have been controlled under NSPS and attention is focused on numerous smaller sources. For this reason, effort should be directed toward the development of a generic environmental impact statement that considers the cumulative effects of both existing and planned NSPS. Such a statement will be of increasing importance to EPA NSPS program planning and for public justification of that plan.

The positive aspects of such a statement would describe the importance of the NSPS-induced reduction in emissions in the national air quality maintenance strategy and show the relation of the NSPS program to other air quality programs. Such a study would in many respects be an extension and more detailed consideration of various analyses presented in this report. To the extent possible, the cost effectiveness of the NSPS approach should also be evaluated and compared with alternative approaches such as retrofit of existing sources.

6.5.3 Development and Review Procedures for EIS

Having defined the desirable contents for specific and general Environmental Impact Statements for NSPS, consideration must be given to EPA mechanisms for generating the statements, personnel and funding required, and review procedures. These considerations are of importance because of the conflicting need to develop standards as soon as possible and the need to develop meaningful and thorough impact statements.

The studies with general applicability identified above can be performed largely independent of the development of any specific NSPS and as such could be performed by EPA contractors. These studies primarily involve the compilation, review, and analysis of existing information and would require an initial effort of approximately 3-4 man-years with an on-going effort of approximately 1 man-year for updating of the information and reassessing impacts of on-going standards.

Although the EIS for specific pollutants as described above are extensive, the additional manpower required should be less than 10% of the total effort required for standard development. This small increment is possible through the use of relatively standard formats making use of information already contained in the support document or in the general statements described above. For maximum coordination and efficiency, this additional staff should be integrated into the existing organization as opposed to being contained in a functionally separate group.

The CEQ Guidelines for EIS[16] require review of the draft environmental statements by appropriate federal agencies, the EPA, affected state and local environmental agencies, and the public. With the exception of state and local agency reviews, the current NSPS review procedure includes review by these entities. Since the precise location of future sources is unknown, review by affected local agencies is not possible. However, by using the previously discussed projection of regions that are expected to receive maximum impact, the intent of this part of the review guideline can be carried out by requesting these regions to review the EIS. Review by state and local agencies would also be useful but should be at the request of the Regional Offices.

The distribution for review of the draft environmental statement should occur simultaneously with the publishing of the proposed standard. The CEQ Guidelines[16] require that "to the maximum extent practicable no administrative action ...is to be taken sooner than ninety (90) days after a draft environmental statement has been circulated for comment." However, Section 111 of the Clean Air Act requires promulgation of the standard within ninety (90) days after the proposed standard is published and the EPA is legally bound to this schedule. The schedule proposed in Sec. 6.3 provides for 84 days before final action, which is not in major conflict with the CEQ guidelines.

APPENDIX A. Projected National Mobile Source Emissions

Projections of national mobile source emissions were computed from the relation:

$$(\text{Mobile source emissions, year Y}) = (\text{Mobile source emissions, 1972}) \times (1.02)^{Y-1972} \times \frac{\text{average emissions per vehicle, year Y}}{\text{average emissions per vehicle, 1972}}$$

The National Emission Data System (NEDS),[12] which was used to estimate the 1972 mobile source emissions as shown in Table A-1.

Table A-1. 1972 NEDS Land Vehicle Emissions

Pollutant	Emissions 10^6 tons/year
CO	76.01
HC	14.61
NO_x	8.52
Particulates	0.52
SO_x	0.51

The average emissions per vehicle for the various years were determined from Supplement 5 to Ref 20 which is the latest published EPA data on vehicle emissions. The emission factors for each model year for each vehicle class includes appropriate weighting factors for deterioration, age distributions, miles traveled for model year, and cold-start emissions. Evaporative and crankcase hydrocarbon emissions are also added. For this study, the low-altitude emission factors were assumed to apply nationwide. No adjustments were made for region-specific Transportation Control Plans.

The second factor in the above equation simulated a 2% compound growth rate in number of vehicle-miles traveled.

The projected total mobile source emissions are shown in Fig. A-1. Because of the various assumptions used in this analysis, the projections should not be considered as a precise portrayal of future mobile source emissions, in particular because of possible changes in emission regulations.

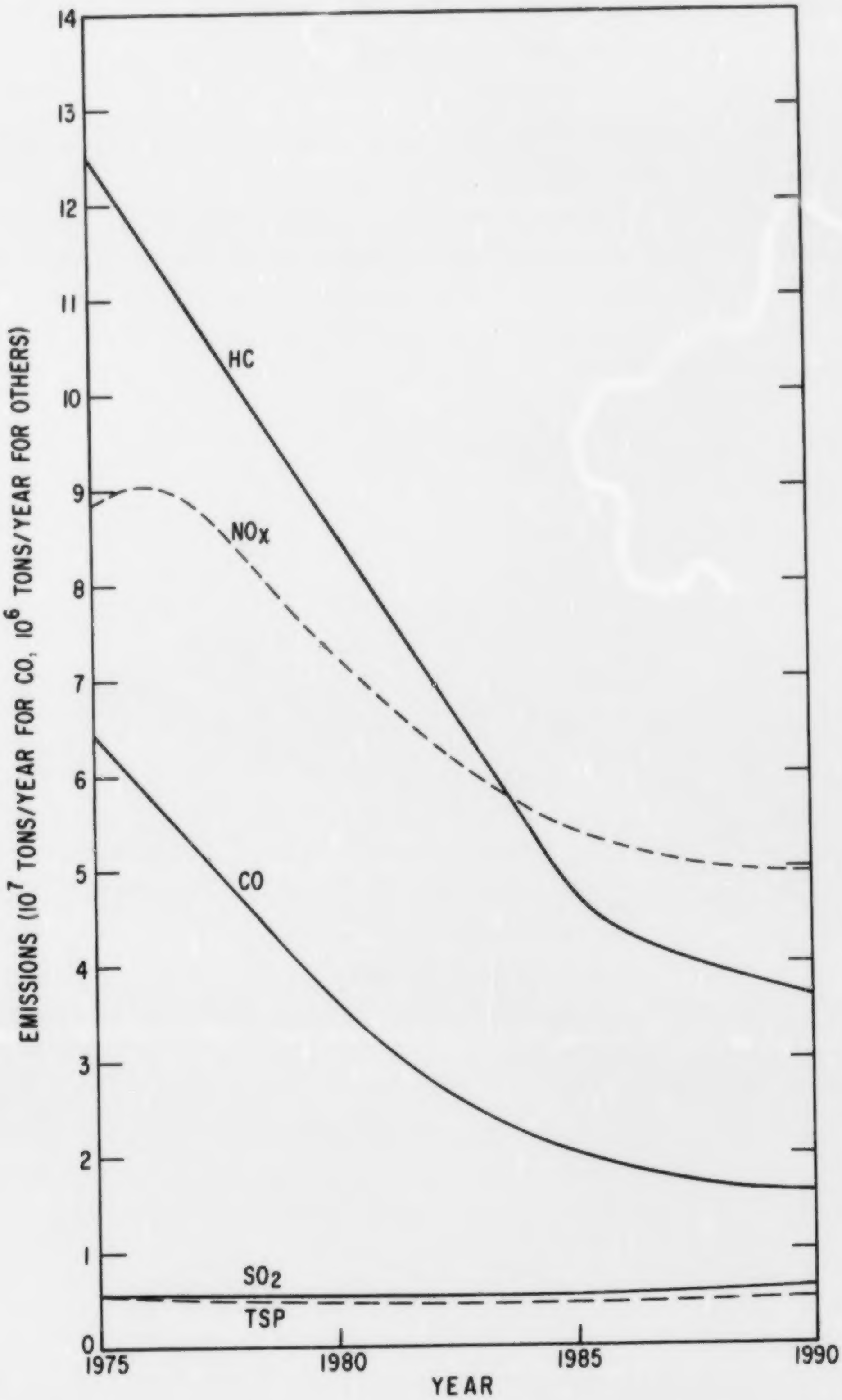

Fig. A-1. Emission Projections for Mobile Sources

However, the estimates should be sufficient to show trends of combined mobile source emissions and the point source emissions analyzed in the main text of this report.

One additional point needs to be emphasized. The NO_x vehicle emission rates used here assume that the statutory limit of 0.4 grams/mile will be implemented in 1978. There is significant question as to if, and when, this limit will actually be achieved due to amendments to the Clean Air Act currently under consideration. Nevertheless, use of the 0.4 grams/mile value here represents a conservative approach by assuming the best possible control on mobile sources.

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